

CHAPTER III

ENVIRONMENTAL CONSEQUENCES

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INTRODUCTION

Implementing the CVPIA will affect the aquatic ecosystem throughout both the Sacramento and San Joaquin River regions (Figure III-1). The changes in aquatic environmental conditions will be complex and extensive, affecting fish resources in reservoirs, major rivers, tributary streams, the Sacramento-San Joaquin Delta estuary, and the Pacific Ocean. In this chapter, the direct and indirect impacts on and benefits to the aquatic ecosystem of implementing the CVPIA are assessed. The five alternatives that are the basis of the PEIS, including the No-Action Alternative, represent a range of actions that vary in the level of potential improvements to, and potential impacts on, aquatic habitats. A detailed description of the alternatives included in the PEIS is provided in the Alternatives Description Technical Appendix. The impacts and benefits of implementing each alternative are assessed in this chapter, and the results are presented compared to the No-Action Alternative.

This chapter contains four primary sections,

- a summary of the impacts of all of the alternatives,
- a brief section discussing the programmatic level of analysis,
- a detailed section describing the impact assessment methodology, and
- a section detailing the expected beneficial and adverse impacts resulting from each of the action alternatives.

IMPACT SUMMARY AND COMPARISON OF ALTERNATIVES

This section summarizes and compares the differences among all alternatives discussed in detail in the following sections. Overall, CVPIA provisions and specific restoration actions developed by the Service through the Anadromous Fish Restoration Program included in each alternative benefit all representative species (Table III-1). A summary of the restoration actions developed by the Service is presented in PEIS Attachment F. Actions related to flow, structures, habitat, and species management reduce loss of individual organisms, increase habitat availability, and increase the geographic distribution and abundance of most representative species relative to the No-Action Alternative. The CVPIA actions should also increase the likelihood that species will survive and maintain productivity during natural and human-caused changes to future environmental conditions.

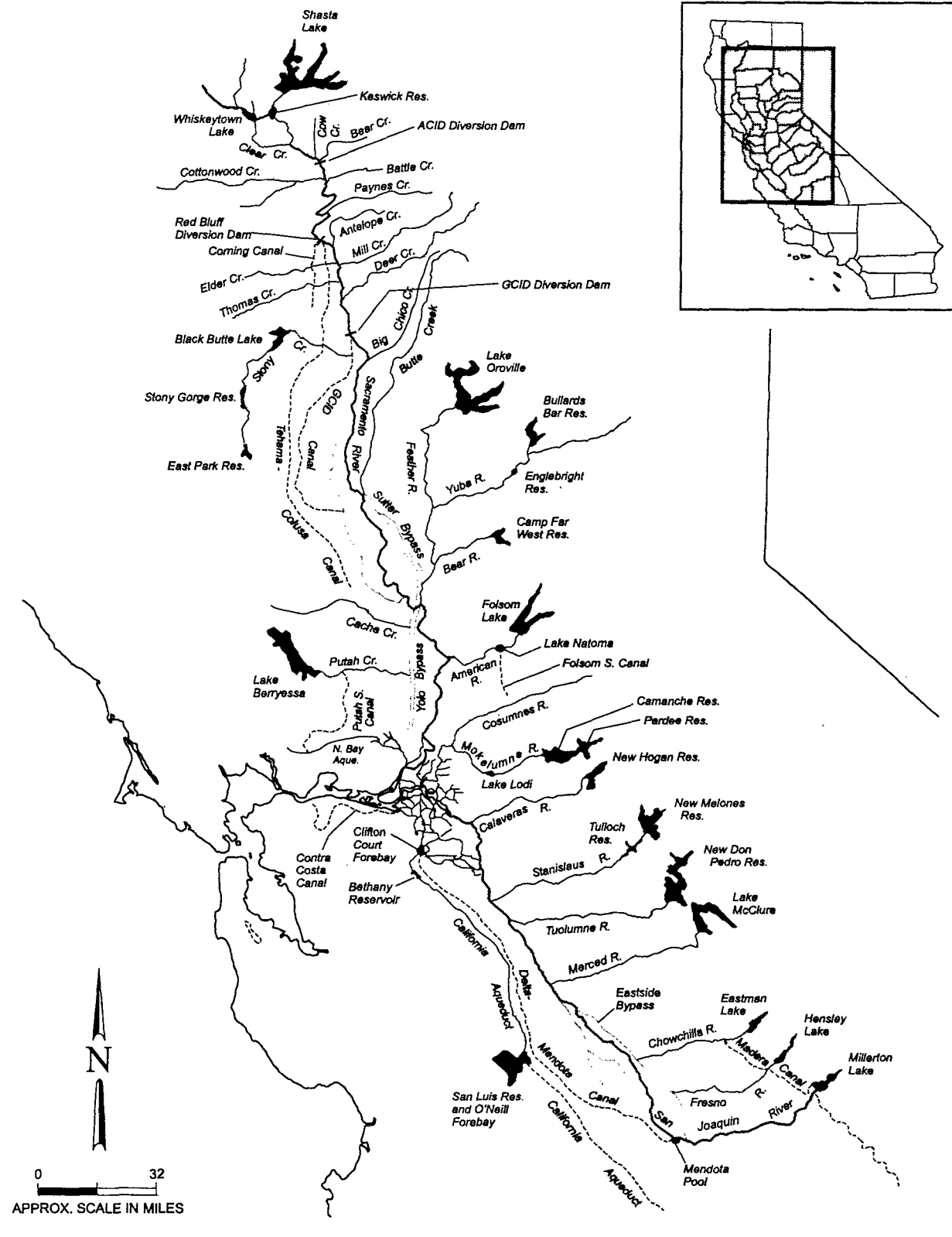


FIGURE III-1

**RIVER, RESERVOIR, AND ESTUARINE AQUATIC
HABITATS AFFECTED BY THE CVPIA**

TABLE III-1

**SUMMARY OF BENEFITS AND ADVERSE IMPACTS ON
FISHERY RESOURCES FOR ALL PEIS ALTERNATIVES****BENEFITS:****Alternative 1**

Increased habitat and food web support would result from habitat restoration actions to restore spawning substrate, rearing habitat, riparian habitat, shallow-water habitat, and river meander dynamics.

Removal of barriers and other improvements to fish passage would increase access of adults to habitat and reduce loss of juveniles during downstream migration.

Increased food web support and reduced loss of most fish life stages would result from actions to reduce pollutant input.

Loss of juvenile and adult fish would be reduced by construction of, and improvements to, fish screens on existing diversions and/or the removal of diversions. Losses at diversions would be reduced for all life stages because of reduced diversions in the Delta from April through August (except under Alternative 3).

Loss of eggs and juvenile fish in rivers would be reduced by actions that address reservoir operations due to short-term water surface-level change.

Additional flow in Clear Creek and the Stanislaus River would provide additional spawning and rearing habitat and reduce loss to adverse water temperature.

Increased Delta outflow and a resulting downstream shift in estuarine salinity would reduce losses to diversion and increase habitat and food web support during January through March.

Alternative 2

Benefits of Alternative 1, plus

Increased flow in the Stanislaus, Tuolumne, and Merced rivers would increase spawning and rearing habitat and reduce losses to adverse water temperature.

Increased Delta outflow would reduce losses to diversion and increase habitat and food web support during January through March.

Alternative 3

Benefits of Alternative 2, plus

Increased flow in the Mokelumne, Stanislaus, Tuolumne, Merced, Yuba, and Calaveras rivers would increase spawning and rearing habitat and reduce losses to adverse water temperature.

Increased Delta outflow would reduce losses to diversion and increase habitat and food web support during January through March.

Alternative 4

Benefits of Alternative 3, plus

Reduced Delta diversions and increased Delta outflow would reduce losses to diversion and increase habitat and food web support during most months.

TABLE III-1. CONTINUED

ADVERSE IMPACTS:**Alternative 1**

Reduced habitat availability and increased losses of planktonic eggs would result from reduced flows in the Sacramento River and the reduced downstream extent of cool water.

Reduced habitat availability and increased mortality during spawning and rearing life stages in response to increased spring, summer, and early fall water temperatures in the American, and Merced rivers.

Increased Delta diversions from October through January may increase losses of juvenile fish.

Reduced Delta outflow from July through November could reduce habitat availability, increase losses to diversion, and reduce food web support (except under Alternative 4).

Alternative 2

Reduced habitat availability and increased losses of planktonic eggs would result from reduced flows in the Sacramento River and the reduced downstream extent of cool water.

Reduced habitat availability and increased mortality during spawning and rearing life stages in response to increased spring, summer, and early fall water temperatures in the American River.

Increased Delta diversions from October through January may increase losses of juvenile fish.

Reduced Delta outflow from July through November could reduce habitat availability, increase losses to diversion, and reduce food web support.

Alternative 3

Reduced habitat availability and increased losses of planktonic eggs would result from reduced flows in the Sacramento River and the reduced downstream extent of cool water.

Reduced habitat availability and increased mortality during spawning and rearing life stages in response to increased spring, summer, and early fall water temperatures in the American River.

Increased Delta diversions would increase loss of all life stages, especially during March, April, and May.

Alternative 4

Reduced habitat availability and increased losses of planktonic eggs would result from reduced flows in the Sacramento River and the reduced downstream extent of cool water.

Reduced habitat availability and increased mortality during spawning and rearing life stages in response to increased spring, summer, and early fall water temperatures in the American River.

Increased Delta diversions would increase loss of all life stages, during October through December (low diversion years only) and January through March.

CVPIA ACTIONS

Structural, habitat, and species management actions are the same for Alternatives 1 through 4 and provide substantial benefits relative to the No-Action Alternative. Structural changes include removing, constructing, and modifying barriers; making fish screen improvements; and constructing and reoperating temperature control structures (Table III-2), per December 1995 AFRP Draft Restoration Plan. Fish screen improvements included in Alternatives 1 through 4 include constructing new fish screens, improving bypass flows, reducing handling mortality (for salvaged fish), and reducing predation that may be attributable to structures and flow conditions associated with diversions. Benefits that accrue to aquatic species from structural changes include reduced water temperature and diversion, improved conditions affecting movement, and improved access to essential habitat.

Habitat restoration actions assumed to be implemented under the CVPIA alternatives include restoring riparian and shallow water habitats in the Delta, restoring meander corridors along selected rivers, watershed management programs, reducing pollutants, and restoring salmonid spawning and rearing habitats (Table III-3), per December 1995 AFRP Draft Restoration Plan. Benefits that accrue to aquatic species from habitat restoration actions are reduced water temperature and pollutants and increased habitat quantity and quality, access to habitat, and food web support.

Most species management actions are not clearly defined in the CVPIA, and change in the environmental conditions and associated beneficial and adverse impacts cannot be determined with the available information. Species management actions include rehabilitating and expanding the Coleman National Fish Hatchery; DFG actions to augment the striped bass population; and, possibly, removing predators associated with diversions, barriers, gravel ponds, and other human-induced conditions.

Although structural, habitat, and species management actions are the same for Alternatives 1 through 4, benefits to Delta and riverine species progressively increase in response to increased volume and increased number of rivers where flow is acquired for aquatic resource benefits. In general, flows improve fish habitat conditions under Alternatives 1 through 4 compared to the No-Action Alternative (Table III-4), per December 1995 AFRP Draft Restoration Plan. Flow needs are based on flow recommendations developed by the Service as part of the Anadromous Fish Restoration Program (PEIS Attachment G) (Service, 1995a, 1995b). This target flow information is presented in PEIS Attachment F. In addition, Alternatives 1 through 4 may include Delta structural changes that affect flow, including adding and operating a Georgiana Slough barrier and operating a barrier at the head of Old River (effects of structural changes are discussed in Alternative 1b).

Water acquired increase streamflows, which affect nearly all environmental conditions, creating benefits to and adverse impacts on all representative species. Benefits that accrue to aquatic species from flow-related actions include reduced water temperature, diversion, and surface level fluctuation and improved conditions affecting movement, quantity and quality of habitat, and food web support.

TABLE III-2

SUMMARY OF CVPIA STRUCTURE-RELATED ACTIONS

Alternative	Watershed Compartment	Structural Change
No Action	Sacramento River	Modify ACID Diversion Dam operations
No Action	Sacramento River	Raise RBDD gates (September to May)
No Action	Sacramento River	Construct Keswick Dam escape channel
No Action	Delta	Close DCC gates up to 45 days in November to June
No Action	Delta	Open DCC gates when striped bass and sensitive species are abundant in the lower San Joaquin River
No Action	Delta	Close Georgiana Slough barrier in November to April
No Action	Upper Sacramento River	Fish screen - GCID
No Action	Upper Sacramento River	Fish screen - agricultural
1-4	Clear Creek	Construct passage at diversion dam
1-4	Cow Creek	Construct passage at diversion dam
1-4	Cow Creek	Fish screen - agricultural
1-4	Cottonwood Creek	Erect barrier at Crowley Gulch
1-4	Cottonwood Creek	Modify passage at ACID siphon
1-4	Battle Creek	Modify passage past hatchery
1-4	Battle Creek	Erect barrier at Gover Diversion Dam
1-4	Battle Creek	Modify passage past dams
1-4	Battle Creek	Fish screen - power
1-4	Thomes Creek	Modify passage past diversion dams
1-4	Elder Creek	Modify passage over canal siphons and dams
1-4	Mill Creek	Remove dam
1-4	Big Chico Creek	Install Iron Canyon fish ladder
1-4	Big Chico Creek	Install Lindo Channel fishway
1-4	Big Chico Creek	Fish screen - agricultural
1-4	Butte Creek	Install fish ladders
1-4	Butte Creek	Remove dams
1-4	Butte Creek	Fish screen - agricultural
1-4	Feather River	Remove barriers to improve passage
1-4	Yuba River	Install fish ladders past diversions
1-4	Yuba River	Improve dam spill structure
1-4	Yuba River	Modify fish ladder at Daguerre Point Dam
1-4	Yuba River	Fish screen - agricultural
1-4	Yuba River	Fish screen - YCWA, South Brophy
1-4	Bear River	Remove culvert crossing
1-4	Bear River	Fish screen - agricultural
1-4	American River	Fish screen - municipal
1-4	Mokelumne River	Improve passage at Woodbridge Irrigation District
1-4	Mokelumne River	Diversion Dam
1-4	Mokelumne River	Fish screen - agricultural
1-4	Calaveras River	Modify passage at diversion dams
1-4	Calaveras River	Fish screen - agricultural
1-4	Merced River	Fish screen - agricultural
1-4	Tuolumne River	Fish screen - agricultural
1-4	Stanislaus River	Fish screen - agricultural
1-4	San Joaquin River	Erect barrier above Merced River confluence
1-4	San Joaquin River	Fish screen - agricultural
1-4	Delta	Construct seasonal barrier at Old River, operate in April and May
1-4	Delta	Fish screen - all

TABLE III-3

SUMMARY OF CVPIA FISH HABITAT RESTORATION ACTIONS

Alternative	Watershed Compartment	Habitat Restoration Action
1-4	Sacramento River	Restore meander belt: Keswick to Chico
1-4	Sacramento River	Enhance spawning gravel
1-4	Sacramento River	Remedy problems associated with metal sludge in Keswick Reservoir
1-4	Clear Creek	Enhance spawning gravel
1-4	Clear Creek	Initiate erosion control measures
1-4	Clear Creek	Prevent further degradation and restore channel
1-4	Cow Creek	Exclude livestock from riparian habitat
1-4	Cottonwood Creek	Enhance spawning gravel
1-4	Cottonwood Creek	Restore watershed and riparian habitat
1-4	Cottonwood Creek	Cooperative development of criteria
1-4	Paynes Creek	Enhance spawning gravel
1-4	Antelope Creek	Improve stream channel
1-4	Elder Creek	Initiate erosion control measures
1-4	Mill Creek	Cooperative watershed management plan
1-4	Mill Creek	Enhance spawning gravel
1-4	Mill Creek	Restore riparian habitat
1-4	Thomes Creek	Enhance spawning gravel
1-4	Thomes Creek	Cooperative watershed management plan
1-4	Thomes Creek	Initiate erosion control measures
1-4	Thomes Creek	Cooperative development of gravel mining criteria
1-4	Deer Creek	Cooperative watershed management plan
1-4	Deer Creek	Enhance spawning gravel
1-4	Deer Creek	Restore riparian habitat
1-4	Deer Creek	Implement flood management plan
1-4	Big Chico Creek	Enhance spawning gravel
1-4	Big Chico Creek	Initiate cleaning procedures at pools
1-4	Big Chico Creek	Restore riparian habitat
1-4	Butte Creek	Cooperative watershed management plan
1-4	Feather River	Enhance spawning gravel
1-4	Yuba River	Restore stream channel and riparian habitat
1-4	Yuba River	Create side channels for spawning habitat
1-4	Yuba River	Create side channels for rearing habitat
1-4	Yuba River	Purchase streambank conservation easements
1-4	American River	Enhance spawning gravel
1-4	American River	Terminate woody debris removal program
1-4	American River	Improve and protect riparian habitat and instream cover
1-4	American River	Restore rearing habitat
1-4	Mokelumne River	Enhance spawning gravel
1-4	Mokelumne River	Restore riparian habitat
1-4	Mokelumne River	Restore rearing habitat
1-4	Mokelumne River	Cooperative development of gravel mining criteria
1-4	Mokelumne River	Cleanse and reduce sedimentation of spawning gravel

TABLE III-3. CONTINUED

Alternative	Watershed Compartment	Habitat Restoration Action
1-4	Merced River	Enhance spawning gravel
1-4	Merced River	Restore riparian habitat
1-4	Tuolumne River	Enhance spawning gravel
1-4	Tuolumne River	Restore riparian habitat
1-4	Stanislaus River	Restore riparian habitat
1-4	Stanislaus River	Restore rearing habitat
1-4	Stanislaus River	Cooperative development of future bank protection activities
1-4	Stanislaus River	Enhance spawning gravel
1-4	San Joaquin River	Restore riparian habitat
1-4	San Joaquin River	Ensure long-term sustainability of water quality
1-4	Delta	Evaluate opportunities to create tidal shallow-water habitat to increase rearing habitat for anadromous fish
1-4	Delta	Evaluate benefits and opportunities to increase salmonid production through improved riparian habitats
1-4	Delta	Evaluate benefits of a channel buffer zones to enhance riparian areas and reduce sedimentation

TABLE III-4
SUMMARY OF CVPIA FLOW-RELATED ACTIONS

Alternative	Watershed Compartment	Flow-Related Actions
No-Action	Sacramento River	Set minimum flows at Keswick and RBDD for winter-run chinook salmon
1-4	Sacramento River	Increase carryover storage to provide fall flows
1-4	Sacramento River	Maintain flows and implement a schedule for flow changes to avoid redd dewatering and isolating or stranding juvenile anadromous salmonids
1-4	Sacramento and Feather rivers	Maintain adequate flows for sturgeon from February to May for migration, spawning, egg incubation, and rearing consistent with actions to protect anadromous salmonids
1-4	Sacramento River	Maintain adequate flows for American shad from April to June for spawning, incubation, and rearing consistent with actions to protect anadromous salmonids
1-4	Clear Creek	Provide sufficient flows to sustain all life stages of chinook salmon and steelhead trout
1-4	Clear Creek	Release 200 cfs from October 1 through June 1 from Whiskeytown Dam for spring-, fall-, and late fall-run chinook salmon spawning, incubation, and emigration; gravel restoration; spring flushing; and channel maintenance
1-4	Clear Creek, American, and Stanislaus rivers	Change flow patterns to meet Anadromous Fish Restoration Program goals for chinook salmon and steelhead trout as part of the Dedicated Water Methodology
1-4	Feather River	Improve flows for all life stages of fall- and spring-run chinook salmon and steelhead trout
1-4	Feather River	Evaluate the response of spawning salmonids to increased flow in the low-flow channel
1-4	Feather River	Improve flows for American shad migration, spawning, incubation and rearing from April to June
1-4	Yuba River	Reduce and control flow fluctuations for juvenile salmonids
1-4	Bear River	Improve instream flows for all life stages of anadromous salmonids and American shad

TABLE III-4. CONTINUED

Alternative	Watershed Compartment	Flow-Related Actions
1-4	American River	Improve streamflows for all life stages of anadromous salmonids
1-4	American River	Reduce and control flow fluctuations
1-4	American River	Increase flows for American shad migration, spawning, incubation and rearing from April through June by modifying CVP operations, using dedicated water, and acquiring water from willing sellers
1-4	American River	Evaluate the effectiveness of pulse flows to facilitate the successful emigration of juvenile salmonids
1-4	Stanislaus River	Develop a carryover storage target for New Melones Reservoir to ensure that Vernalis flow standards are met during the 30-day pulse flow period during the third year of a dry or critical period
1-4	Stanislaus River	Evaluate the use by American shad and consider increasing flows to maintain mean daily water temperatures between 61 degrees and 65 degrees Fahrenheit from April to June, in a manner consistent with actions to protect chinook salmon
1-4	Tuolumne and Merced rivers	Reduce adverse effects of rapid flow fluctuations
1	San Joaquin River	Implement a flow schedule that improves conditions for anadromous salmonids
2	Stanislaus, Tuolumne, and Merced rivers	Increase flows to meet Bay-Delta pulse flows on the San Joaquin River at Vernalis (flow acquisition is limited by available funds)
2	Tuolumne and Merced rivers	Increase flows to meet Anadromous Fish Restoration Program goals for anadromous salmonids (flow acquisition is limited by available funds)
2	Tuolumne and Merced rivers	Supplement Federal Energy Regulatory Commission flows for all life stages of chinook salmon
2	San Joaquin River	Implement a flow schedule that improves conditions for chinook salmon beyond Alternative 1 (flow acquisition is limited by available funds)
2-4	San Joaquin River	Maintain adequate flows for migration, spawning, incubation, and rearing of sturgeon from February to May, consistent with actions to protect chinook salmon and steelhead trout

TABLE III-4. CONTINUED

Alternative	Watershed Compartment	Flow-Related Actions
3-4	Mill, Deer, and Butte creeks	Increase flows to meet the Anadromous Fish Restoration Program goals for chinook salmon and steelhead trout
3-4	Yuba, Mokelumne, Calaveras, and Stanislaus rivers	Increase flows to meet Anadromous Fish Restoration Program goals for anadromous salmonids (flow acquisition is limited by available funds)
3-4	Tuolumne and Merced rivers	Increase flows to meet Anadromous Fish Restoration Program goals for anadromous salmonids beyond Alternative 2 (flow acquisition is limited by available funds)
3-4	Yuba River	Reduce flow fluctuations to avoid and minimize impacts on rearing juvenile salmonids
3-4	Yuba River	Evaluate the effectiveness of pulse flows to facilitate successful emigration of juvenile salmonids
3-4	Mokelumne River	Reduce and control flow fluctuations
3-4	Mokelumne River	Evaluate the effectiveness of pulse flows to facilitate successful emigration of juvenile salmonids in spring
3-4	Mokelumne River	Increase flows for American shad migration, spawning, incubation, and rearing from April to June by modifying CVP operations, using dedicated water, and acquiring water from willing sellers
3-4	Stanislaus River	Supplement Federal Energy Regulatory Commission flows for all life stages of chinook salmon
3-4	Tuolumne and Merced rivers	Supplement Federal Energy Regulatory Commission flows for all life stages of chinook salmon beyond Alternative 2
3-4	Stanislaus, Tuolumne, and Merced rivers	Increase flows to meet Bay-Delta pulse flows on the San Joaquin River at Vernalis beyond Alternative 2 (flow acquisition limited by available funds)
3	San Joaquin River	Implement a flow schedule that improves conditions for chinook salmon beyond Alternative 2 (flow acquisition limited by available funds)
4	Sacramento River	Maintain at least 13,000 cfs daily flow at the I Street Bridge during May
4	San Joaquin River	Implement a flow schedule that improves conditions for chinook salmon beyond Alternative 3 (flow acquisition limited by available funds)

TABLE III-4. CONTINUED

Alternative	Watershed Compartment	Flow-Related Actions
4	San Joaquin River	Develop and implement an export schedule that will protect chinook salmon
4	San Joaquin River	Maintain adequate flows for migration, spawning, incubation, and rearing of sturgeon from February to May, consistent with actions to protect chinook salmon and steelhead trout
4	Delta	Implement short pulses of increased flow for migrating fish
4	Delta	Maintain average export to inflow ratio of no more than 45 percent during February in dry years by increasing the ratio to approximately 55 percent in early February and decreasing to 35 percent in late February, when winter-run smolts are present
4	Delta	Limit the combined SWP and CVP exports to 1,500 cfs or maintain a Vernalis inflow to total export ratio of 5 to 1 during the April and May pulse flow period
4	Delta	Limit the combined SWP and CVP exports to 1500 cfs and increase the Vernalis pulse flow period to more than the 30 days required by the Water Quality Control Plan, when San Joaquin River chinook salmon smolts are abundant and water temperatures are below 68 degrees Fahrenheit
4	Delta	Reduce exports and increase Delta outflow from April through July to begin restoration of striped bass production
4	Delta	Supplement Delta outflow for migration and rearing of sturgeon, striped bass, and American shad by modifying CVP operations
4	Delta	Minimize the extent of possible riparian diversions during April through May pulse flows
4	Delta	Evaluate the effects of net reversal flows on juvenile salmonids migrating in the San Joaquin River near the mouth of the Mokelumne River with an intensive monitoring program
4	Delta	Evaluate the effects of pulse flows on chinook salmon migration
4	Delta	Allow acquired and B2 water to flow through the Delta without pumping

The ability to meet fish flow needs under Alternative 1 is determined by base flow operations, reoperation in accordance with Section 3406(b)(1), and the availability of CVP water dedicated to aquatic resource restoration (under Section 3406[b][2] of the CVPIA). Water is obtained in the American and Stanislaus rivers and in Clear Creek so flows are above those under the No-Action Alternative in these rivers. Less water is available in the Sacramento River under Alternative 1 because of reduced imports from the Trinity River (i.e., flow that is required for aquatic resource restoration needs on the Trinity River). Water acquired for aquatic resource restoration affects streamflow and diversion, reservoir operations, water temperature, Delta outflow, net channel flow, and diversion. Alternative 2 is similar to Alternative 1, except that part of the restoration fund may be used to purchase water from non-CVP sources under Section 3406(b)(3) of the CVPIA. The additional water affects primarily the Stanislaus, Tuolumne, and Merced rivers. The change in river flow also affects New Melones and New Don Pedro reservoirs, Lake McClure operations, and Delta outflow.

Alternative 3 builds on Alternative 2, acquiring additional water primarily on the Yuba, Mokelumne, Stanislaus, Tuolumne, Merced, and Calaveras rivers. Affected reservoirs include Lake Oroville, Camanche Reservoir, New Hogan Lake, New Melones Reservoir, New Don Pedro Reservoir, and Lake McClure. New Bullards Bar Reservoir on the Yuba River would be affected, but the effects could not be determined with available information. As under Alternative 1, the change in river flow affects Delta outflow, net channel flow, and diversion.

The volume of water acquired for instream release under Alternative 4 is the same as for Alternative 3. Under Alternative 4, flow acquired for aquatic resource benefits is not exported from the Delta and, compared to Alternative 3, Delta diversion is reduced, net channel flow is altered, and Delta outflow is increased, providing additional benefits to the representative species. (A similar analysis of restricting export of acquired water under Alternative 1 is described under Supplemental Analysis 1a.)

RESPONSE BY SPECIES

The following section summarizes the main benefits to and adverse impacts on the representative species included in the PEIS.

Chinook Salmon and Steelhead Trout

Chinook salmon and steelhead trout are cold-water species that occur in all the major rivers of the Sacramento and San Joaquin River basins and have the most extensive geographic distribution of all the representative species. Chinook salmon include fall-, late fall-, winter-, and spring-runs. Implementation of the CVPIA actions would improve habitat used by chinook salmon and steelhead trout compared to conditions under the No-Action Alternative.

Throughout the Sacramento and San Joaquin River basins, increased habitat quantity and quality and food web support would benefit spawning-incubation and juvenile life stages. Removing barriers and making other improvements to fish passage would increase access to suitable habitat, especially on tributary streams to the Sacramento River and Clear Creek. Increased habitat quantity and quality and food web support result from actions that would restore spawning substrate, rearing habitat, riparian habitat, and river meander dynamics.

Reduced pollutants, diversion, water surface-level change, and improved movement conditions would also benefit adult, spawning-incubation, and juvenile life stages of chinook salmon and steelhead trout under Alternatives 1 through 4. Loss of juveniles to diversions would be reduced by fish screen improvements throughout the basins and removing diversions from some minor tributary streams would reduce loss of juveniles. CVPIA actions address reservoir operations and would reduce loss of eggs, fry, and juveniles through short-term water surface-level change in the Sacramento, Yuba, American, Tuolumne, and Merced rivers. Removing barriers and making other improvements to fish passage would reduce loss of juveniles on tributary streams, including Clear and Butte creeks and the Yuba River. Constructing barriers to block access to unproductive habitat on some tributary streams and on the mainstem San Joaquin River would improve movement into appropriate habitat. Isolating existing ponds from the main Merced, Tuolumne, and Stanislaus river flow would reduce predation.

Increased flow during spawning and rearing periods could provide additional spawning and rearing habitat. Under Alternatives 1 through 4, additional flow is provided in Clear Creek and the Stanislaus River compared to the No-Action Alternative. Alternative 2 increases flow compared to Alternative 1 in the Stanislaus, Tuolumne, and Merced rivers. Alternatives 3 and 4 increase flow compared to Alternatives 1 and 2 in the Mokelumne, Stanislaus, Tuolumne, Merced, Yuba, and Calaveras rivers.

Under Alternatives 1 through 4, water temperature would be reduced by increased flow and cooler water temperature in Clear Creek and the Stanislaus River, benefiting juvenile chinook salmon and steelhead trout. Further improvements to temperature conditions would accrue to chinook salmon under Alternatives 2, 3, and 4 in the Stanislaus, Tuolumne, and Merced rivers. Additional improvements to temperature conditions would occur under Alternatives 3 and 4 in the Mokelumne, Stanislaus, Tuolumne, Merced, Yuba, and Calaveras rivers.

Not all actions implemented under Alternatives 1 through 4 would benefit fall-run chinook salmon in the Sacramento River basin. From May through September, water temperature would increase and would exceed optimal levels in habitat downstream of RBDD. Compared to the No-Action Alternative, increased temperature and reduced flow under Alternatives 1 through 4 would reduce spawning and rearing habitats available to chinook salmon and steelhead trout. Although increased temperature could reduce available habitat, water temperature in upstream reaches would remain within the optimal range and water temperature farther downstream would continue to be determined by ambient conditions. Restoration actions that reduce pollutant concentrations and increase habitat through restoration would lessen flow and temperature effects.

In the American and Stanislaus rivers, elevated water temperature under Alternatives 1 through 4 would increase loss during spawning-incubation and rearing life stages, primarily during late summer and early fall, for chinook salmon and steelhead trout compared to the No-Action Alternative. Restoration actions for reoperating or reconfiguring multilevel release shutters would improve water temperature conditions compared to conditions indicated by the simulated temperature under Alternatives 1 through 4.

Operations under Alternative 1 on the Merced River could increase water temperature and reduce cool-water habitat availability during April and May. Chinook salmon in the Merced River,

however, would benefit from increased flow and potentially cooler water under Alternative 2 and, increasingly, Alternatives 3 and 4.

In the Sacramento-San Joaquin Delta estuary, chinook salmon would benefit under Alternatives 1 through 4 from reduced pollutants and diversion, and increases in suitable habitat and food web support. Increases in suitable habitat and food web support would result from actions that would restore shallow water and riparian habitats benefiting juveniles during temporary residence and migration through the Delta.

Under Alternatives 1, 2, and especially 4, loss of juvenile chinook salmon (primarily fall-run) and steelhead trout to diversions would be reduced by fish screen improvements and by reduced Delta diversion during April, May, and June. Under Alternative 3, diversion from February through May would increase loss of juvenile chinook salmon and steelhead trout compared to the No-Action Alternative and Alternatives 1, 2, and 4. Fish screen improvements would lessen the impact of the Alternative 3 diversion increases.

For juvenile chinook salmon and steelhead trout migrating down the Sacramento River, increased movement into the central Delta through the DCC and Georgiana Slough would occur during June under Alternatives 1 through 4. However, a higher QWEST during April, May, and June would benefit movement by reducing attraction into the central and south Delta under Alternative 1 and increasingly under Alternatives 2, 3, and especially 4. Adverse changes in conditions affecting movement and diversion under Alternatives 1 through 4 would increase in response to reduced QWEST and increased diversion from November through February. Adverse effects may be partially offset by fish screen improvements.

Sturgeon

The assessment of impacts on sturgeon encompasses both white and green sturgeon species. Actions implemented under Alternatives 1 through 4 would improve habitat conditions for sturgeon compared to conditions under the No-Action Alternative. The population would benefit most from increased quantity and quality of habitat and food web support, derived primarily from restoration of riparian habitat, river meanders, and shallow water habitat in the Delta. Reduced pollutant levels would also benefit sturgeon, especially because of their longevity and residence in the Sacramento-San Joaquin Delta estuary.

American Shad

American shad would benefit from CVPIA actions implemented under Alternatives 1 through 4. Compared to the No-Action Alternative, benefits would accrue during all life stages in response to reduced pollutant levels and diversions and increased suitable habitat and food web support. Juvenile American shad would benefit from fish screen improvements that would reduce diversion-related losses. In addition, reduced Delta diversions during June and July under Alternatives 1 through 4 would reduce losses of egg, larval, and juvenile shad occurring in Delta habitats. Restoring riparian habitat and river meanders could increase habitat and food availability for juvenile American shad rearing in the Sacramento and Feather rivers. Restoring shallow water habitat in the Delta would benefit juvenile American shad rearing in Delta habitat.

Although American shad would benefit from the total package of CVPIA actions implemented under Alternatives 1 through 4, not all actions would be beneficial. Reduced flow in the Sacramento and American rivers during May, June, and July may increase mortality of eggs and larvae. Under Alternatives 1 through 4, Delta diversions from October through November (and during September under Alternative 3) would generally increase and may increase entrainment of outmigrant juvenile American shad. Fish screens constructed and improved salvage operations implemented under the CVPIA, however, would reduce losses of affected fish.

In addition, food web support may be reduced compared to the No-Action Alternative. The upstream shift in estuarine salinity caused by reduced Delta outflow from July through October under Alternatives 1 through 3 would reduce food availability during shad outmigration. CVPIA actions that may lessen the adverse effects of reduced Delta outflow on food availability include habitat restoration actions in the Delta and reducing the input of pollutants.

Striped Bass

Many actions implemented under Alternatives 1 through 4 would benefit striped bass. Benefits would accrue during the egg, larval, and juvenile rearing life stages in response to reduced pollutant levels and diversions; beneficial conditions affecting movement; and increased suitable habitat and food web support. Adult striped bass would benefit from reduced pollutant levels and increased habitat and food web support.

Juvenile striped bass would benefit from fish screen improvements that would reduce diversion-related losses. In addition, reduced Delta diversions from April through August under Alternatives 1, 2, and especially 4, and during June and July under Alternative 3 would reduce losses of egg, larval, and juvenile striped bass. QWEST would be lower compared to the No-Action Alternative and would benefit movement of organisms out of the central and south Delta. An upstream shift in estuarine salinity during July and August under Alternatives 1 through 3, however, would moderate the potential benefit of a higher QWEST. Restoring shallow water and riparian habitats in the Delta would also benefit juvenile striped bass by increasing habitat availability and food web support.

Striped bass would be adversely affected by increased diversion, unfavorable conditions affecting movement, and reduced quantity and quality of habitat. Reduced flow in the Sacramento River under Alternatives 1 through 4 during the egg and larval life stages would increase mortality through delayed movement and increased settling compared to the No-Action Alternative. The contribution of Sacramento River spawners (greater than 50 percent of the population) to year class abundance would be adversely affected.

In the Delta, the proportion of eggs and larvae entering the central Delta from the Sacramento River through the DCC would increase during June and possibly July. The influence of diversions in the central Delta is generally greater than diversion effects farther downstream. As previously noted, however, active movement into the Delta and diversions would be reduced during May through August, offsetting the adverse effects of DCC transport under Alternatives 1, 2, and 4 (but not under Alternative 3 during May). Under Alternative 3, increased diversion during April and May would increase loss of striped bass eggs, larvae, and juveniles.

Delta diversions from October through January would generally increase under Alternatives 1 through 4 and would increase loss of juvenile striped bass, both to diversions and conditions affecting movement. Less flow toward Suisun Bay and increased flow toward the SWP and CVP diversions would reduce movement out of the less productive habitat in the central Delta toward Suisun Bay. Fish screens constructed and improved salvage operations implemented under the CVPIA, however, would reduce the loss of juvenile bass.

In addition, habitat and food availability would be reduced compared to the No-Action Alternative by the upstream shift in estuarine salinity caused by reduced Delta outflow during July through November under Alternatives 1 through 3. CVPIA actions that would alleviate adverse effects of reduced Delta outflow on habitat and food availability include habitat restoration actions in the Delta and reducing the input of pollutants.

Delta Smelt, Longfin Smelt, and Sacramento Splittail

Compared to the No-Action Alternative, benefits under Alternatives 1 through 4 would accrue during all life stages of delta smelt, longfin smelt, and Sacramento splittail in response to reduced input of pollutants, reduced diversions, improved conditions affecting movement, and increased habitat and food web support. Eggs and larvae would benefit from reduced pollutant concentrations. Larvae, juveniles, and adults would benefit from reduced pollutants, reduced diversion, and habitat restoration.

Juvenile and adult delta smelt, longfin smelt, and Sacramento splittail would benefit from fish screen improvements that would reduce diversion-related losses under Alternatives 1 through 4. In addition, reduced Delta diversions from April through August would reduce loss of larvae, juveniles, and adults under Alternatives 1, 2, and 4. Increased diversion under Alternative 3 would increase loss of larval and juvenile delta smelt, longfin smelt, and Sacramento splittail during March, April, and May.

Under Alternatives 1 through 4, conditions affecting the movement of delta and longfin smelt out of the Delta would improve compared to the No-Action Alternative, primarily in response to a higher QWEST from May through August (but not under Alternative 3 during May). An upstream shift in estuarine salinity during July and August under Alternatives 1 through 3, however, would moderate the potential benefit of a higher QWEST.

Restoring shallow water and riparian habitats in the Delta would benefit adult and juvenile delta smelt, longfin smelt, and Sacramento splittail by increasing spawning and rearing habitat availability and food web support under Alternatives 1 through 4. Restoring the meander belt on the Sacramento River would increase the availability of seasonally inundated habitat, important to splittail spawning success and potentially providing additional food web support. The cumulative flows of Sacramento River at Knights Landing and Feather River at the confluence with the Sacramento River would be similar under Alternatives 1 through 4. Therefore, the frequency of shallow water habitat inundation such as the Yolo Bypass would also be similar under alternatives 1 through 4. For all three species, downstream shift in estuarine salinity in January through March under Alternatives 1, 2, and increasingly for 3 and 4, would increase spawning habitat availability and food web support.

Under Alternatives 1 through 4, increased Delta diversion during October through December would increase the loss of juvenile and adult delta smelt and adult longfin smelt. These losses would increase directly from diversion and indirectly from reduced movement downstream of the influence of diversions. Less flow toward Suisun Bay and increased flow toward the SWP and CVP diversions would reduce smelt movement out of unproductive habitat in the central Delta toward Suisun Bay. Improved fish screens and salvage operations implemented under the CVPIA, however, would help to reduce the loss of affected fish.

In addition, habitat and food availability would be reduced under Alternatives 1 through 3 compared to the No-Action Alternative as a result of the upstream shift in estuarine salinity in response to reduced Delta outflow from July through November during some years. Habitat restoration actions in the Delta and reduced pollutant concentrations would alleviate adverse effects of reduced Delta outflow on habitat and food availability.

Reservoir Species

Changes in reservoir surface elevation affect survival by causing nest desiccation (drying out) and the displacement of juveniles, changes in the quantity and quality of habitat, and changes in food web support. Overall, changes in reservoir operation under Alternatives 1 through 4 would have minimal effects on reservoir species. Although monthly and annual variability in surface elevation is substantial, reflecting a response to meteorology and operations for water storage and flood control needs, changes in reservoir operations between the No-Action Alternative and Alternatives 1 through 4 are small and would have minimal effects on reservoir species. For Alternatives 1 through 4, increased average monthly reservoir surface elevation would benefit largemouth and spotted bass in Lake Oroville and Folsom Lake. Lower average monthly surface elevation and increased drawdown would adversely affect reservoir species in Shasta Lake, Camanche Reservoir, New Hogan Lake, New Melones Reservoir, New Don Pedro Reservoir, and Lake McClure. Effects on New Melones Reservoir, New Don Pedro Reservoir, and Lake McClure increase from Alternatives 1 through 3 (Alternative 4 reservoir operations are the same as Alternative 3). Effects on Camanche Reservoir and New Hogan Lake increase under Alternative 3.

PROGRAMMATIC LEVEL OF ANALYSIS

The impact assessment presented in this chapter consists of qualitative descriptions of potential changes in species populations compared to the No-Action Alternative. Information on many CVPIA actions included in the PEIS alternatives has not yet been sufficiently developed to allow meaningful and accurate descriptions that would support more than a general qualitative assessment.

The CVPIA will implement interrelated actions to restore and improve aquatic environmental conditions and structure. The PEIS includes alternative suites of actions intended to meet the objectives of the CVPIA (see Alternatives Description Technical Appendix). In addition to actions identified in the CVPIA, actions developed by the Service as part of the Anadromous Fish Restoration Program (PEIS Attachment G) are included in the alternatives (Tables III-2, III-3, and III-4).

Flow-related actions include:

- changes in reservoir operations and
- changes in water diversion timing and quantity.

Structure-related actions include:

- relocating and consolidating water diversions,
- constructing and operating fish barriers,
- constructing and improving fish screens, and
- operating multilevel reservoir release structures to meet downstream water temperature needs.

Habitat-related actions include:

- improving water quality (e.g., development of watershed management plans, stream-watch programs) and
- habitat restoration (e.g., restoring riparian zones, meander belts, and spawning and rearing habitat).

Species management actions include:

- removing predators and
- imposing restrictions on the introduction of non-native species.

The impact assessment for each alternative presents a general and qualitative description of potential species population responses to each alternative, compared to conditions under the No-Action Alternative.

Some CVPIA actions, species management actions in particular, are not yet defined in enough detail to allow even a general and qualitative assessment. For that reason, the following actions are not assessed in this PEIS: measures to reduce illegal fishing, management of ocean and river fishing, and changes in artificial production methods (i.e., rehabilitation and expansion of Coleman National Fish Hatchery, striped bass pen rearing, and hatchery programs) (Service, 1995a, 1995b).

Harvest includes commercial fishing, sport fishing, and illegal fishing activities that cause or contribute to the death of individuals in a species population. Artificial production is the human-aided production of a species in a facility that is isolated to some degree from the natural ecosystem (e.g., fish hatchery, rearing pen). Exclusion of harvest and artificial production from this impact assessment (although both processes are mentioned briefly under "Cumulative Impacts") does not imply that harvest and artificial production have minimal effects on species populations or that harvest and artificial production would not affect the outcome of implementing CVPIA actions. Evaluating impacts of harvest and artificial production requires prediction of the effects of CVPIA actions on species population abundance. Such prediction is inappropriate for the PEIS. CVPIA actions and potential effects on environmental conditions are described at a level of detail consistent with the needs of a programmatic document, not at the level of detail needed for predicting changes in species populations. Furthermore, CVPIA actions that could affect harvest and artificial production have not yet been clearly described.

The potential effects of CVPIA actions on aquatic species in CVP and SWP reservoirs and other major terminal reservoirs in the Sacramento River and San Joaquin River regions are analyzed, but the effects on reservoirs upstream of these terminal reservoirs (and the associated stream reaches between reservoirs) are not evaluated in this technical appendix. Operation of reservoirs upstream of the major terminal reservoirs was not simulated and is outside of the scope of this PEIS.

The impacts of implementing some CVPIA actions are being addressed in other documents. CVPIA actions affecting the Trinity River are not discussed directly in the PEIS, but they are addressed in the Trinity River EIR/EIS. The effects of changes in Trinity River exports to the Sacramento River Basin, however, are assessed in this PEIS. Other CVPIA actions are currently being considered under other programs, including the Category III Program (non-flow improvements to fish habitat), SB34 Program (Delta levee improvements); and Endangered Species Act consultation on the Fishery Management Plan for Commercial and Recreational Salmon Fisheries off the coasts of Washington, Oregon, and California.

CVPIA actions addressed in environmental documents that have been completed or may be completed in the future include installing the temperature control device at Shasta Dam, developing a comprehensive plan to be coordinated with the State of California San Joaquin River Management Program, and actions implemented under the federal Endangered Species Act to protect winter-run chinook salmon and delta smelt (e.g., RBDD operations, improvements to GCID's Hamilton City pumping plant).

The site-specific environmental effects of implementing CVPIA actions will need to be addressed in greater detail, as necessary, in site-specific environmental compliance documents. A more detailed discussion of the programmatic nature of this PEIS, how it can be used in implementing portions of the CVPIA, and additional documentation needed to implement the remaining portions of the CVPIA is provided in Chapter VII of the PEIS.

IMPACT ASSESSMENT METHODOLOGY

This analysis qualitatively describes the beneficial and adverse impacts of each of the alternatives on the distribution and abundance of fish species. These effects are always determined by comparing conditions that would occur under an alternative to the conditions that would occur under the No-Action Alternative.

Each of the CVPIA alternatives consists of actions that, either individually or in combination, affect one or more environmental conditions. For the purposes of this analysis, environmental conditions are defined as aspects of the aquatic ecosystem that may change as a result of implementing the actions contained in the alternatives, and that may in turn cause beneficial or adverse effects on representative aquatic species. Assessment relationships have been developed that describe how changes in environmental conditions lead to responses by the representative species (Figure III-2). The specific relationships used in the impact assessment are applicable to each species and life stage based on geographic and monthly occurrence.

As an example, a CVPIA action (install or improve fish screens) would cause a change in an environmental condition (diversion conditions). A specific assessment relationship (installation

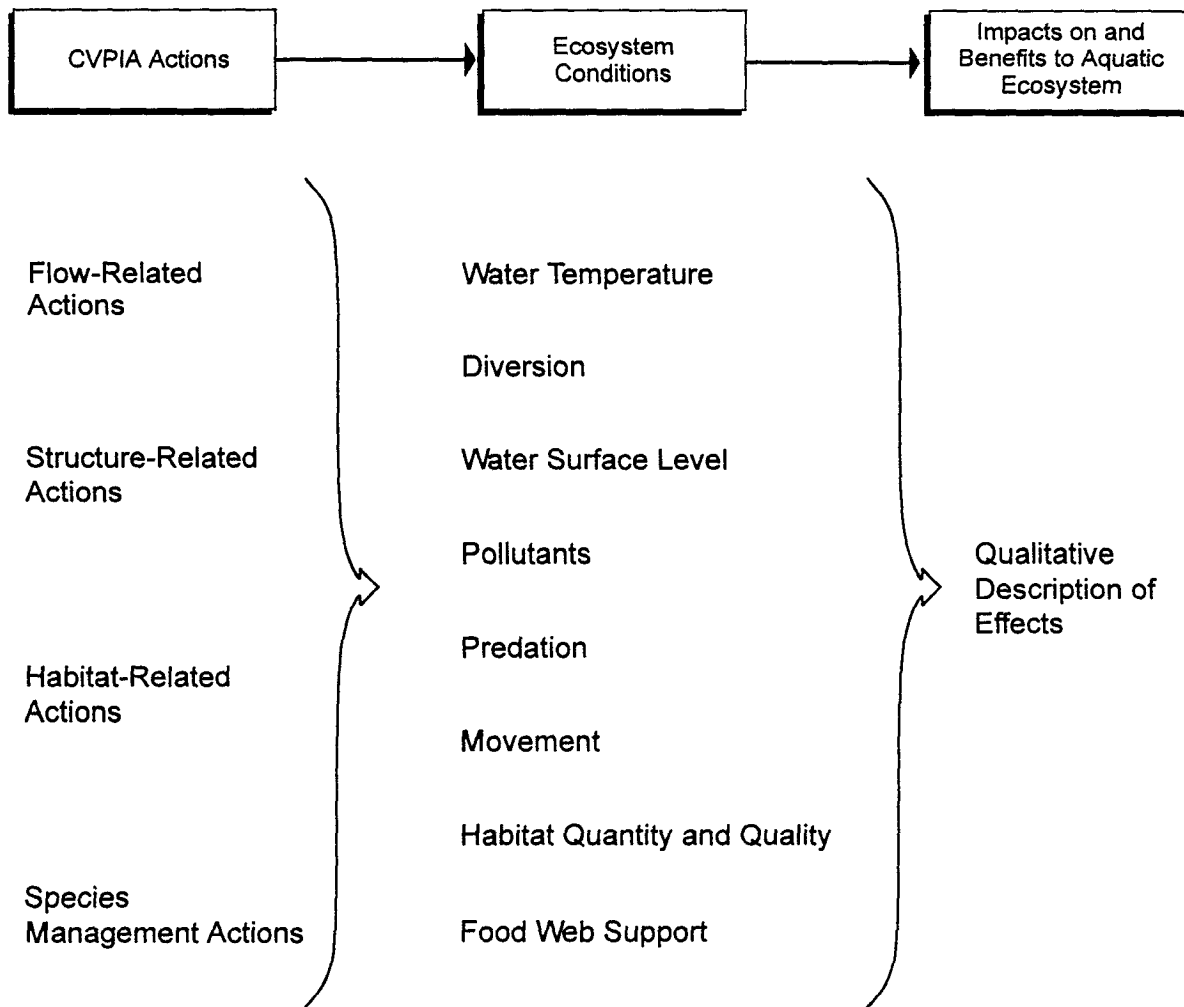


FIGURE III-2

LINKAGE OF CVPIA ACTIONS TO IMPACTS AND BENEFITS

of fish screens decreases entrainment losses for species life stages that are too large to pass through the screen) describes how this change in an environmental condition (reduced fish mortality at certain diversions) results in benefits to individual species (reduced entrainment loss of specific life stages of specific species). In more complex situations, one action may affect several environmental conditions (for instance, reoperation of a reservoir may affect river temperature, diversion conditions, and physical habitat), or one environmental condition may be affected by several actions (diversion conditions may be affected by changes in flow, changes in diversion rates, and installation of fish screens).

Table III-5 summarizes the environmental conditions assessed to determine impacts and benefits on representative species. Detailed definitions of each environmental condition and the specific assessment relationships applicable to them are provided below, following the description of watershed compartments and representative species.

WATERSHED COMPARTMENTS AND REPRESENTATIVE SPECIES

For the purposes of the PEIS, dividing watersheds into compartments and selecting representative species (and life stages) provide a way of managing the assessment of a complex ecosystem. Division of the ecosystem into watershed compartments allows an analysis based on the distinctive characteristics of each geographic component while recognizing the importance of connectivity in maintaining ecosystem values as a whole. The representative species were selected to provide a cross section of the aquatic ecosystem values potentially affected by the CVPIA and restoration actions.

Watershed Compartments

The environmental consequences of implementing the CVPIA are assessed for the aquatic ecosystem encompassed by the Sacramento and San Joaquin River basins, including rivers and reservoirs in the Sacramento River, the San Joaquin River, and the Sacramento-San Joaquin Delta regions (Figure III-1). Watershed compartments are divisions of the aquatic ecosystem, which consist of the connected sequences of water bodies through which aquatic species pass as they complete their life cycles. For the PEIS, watershed compartments include reservoirs, river reaches below the reservoirs, and the Bay-Delta estuary. The watershed compartments for river reaches and for the Bay-Delta estuary were defined based on known habitat use by fish and other aquatic species and potential changes in aquatic habitat conditions expected to occur from implementing the CVPIA (Table III-6).

Dams create substantial barriers between the biological resources in reservoirs and the biological resources in the river reaches below the reservoirs; therefore, the assessments of reservoir species are reservoir-specific. The effects of implementing CVPIA actions are assessed for major reservoirs (Table III-7).

Representative Species

The selection of representative species allows the analysis to be focused while representing ecosystem responses to the full range of changing conditions. The representative species and populations were selected because they depend on ecological processes throughout the ecosystem and are sensitive to an important cross section of affected environmental variables. Species

TABLE III-5

DEFINITIONS OF ENVIRONMENTAL CONDITIONS






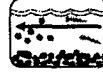


Condition		Definition
Water temperature		Water temperature that exceeds the metabolic tolerances of a species causes or contributes to mortality. Water temperature is primarily a concern for chinook salmon and steelhead trout.
Diversion		Diversions cause fish mortality through entrainment (removal from the ecosystem), impingement on fish screens, abrasion, stress from handling, and increased predation. Diversion is a concern for all representative fish species.
Change in water surface level		Short-term changes in water surface level would cause mortality by exposing redds, stranding individuals, and reducing or eliminating cover. The effects of changes in water surface levels are assessed for representative species in rivers and reservoirs.
Pollution		Pollution includes the entry of substances into the aquatic ecosystem that cause the death of organisms. Increased flow, reduced use of potential pollutants, and actions to clean up pollutant sources reduce the effect of pollution on aquatic organisms.
Predation		Predation is a natural ecosystem function; however, predation could increase to adverse levels through changes in ecosystem structure that increase prey vulnerability or increase predator feeding efficiency.
Movement		Movement, both active and passive, includes the transport of planktonic eggs and larvae and migration to habitat essential for completing an organism's life cycle. Movement is a concern for all representative species.
Habitat quantity and quality		Habitat quantity and quality relate to physical, chemical, and biological conditions that support essential organism activities, including spawning, feeding, respiration, assimilation, predator avoidance, and resting. Habitat quantity and quality are critical in maintaining and increasing all fish populations.
Food web support		Food web support includes nutrient availability, food production, and food availability. Organisms that provide the food base for fish species are affected by the same habitat and ecosystem processes critical to the maintenance and restoration of fish populations. Food web support is essential to maintain all species populations.

TABLE III-6

**DESCRIPTION OF RIVER AND STREAM WATERSHED COMPARTMENTS
INCLUDED IN THE IMPACT ASSESSMENT FOR THE PEIS**

Watershed Compartment	Description
Sacramento River	Keswick Dam downstream to Freeport
Clear Creek	Whiskeytown Dam downstream to the confluence with the Sacramento River
Minor tributaries	Battle, Cow, Cottonwood, Paynes, Antelope, Mill, Deer, Elder, Thomes, Big Chico, Stony, and Butte Creeks; other tributaries, including intermittent streams
Feather River	Thermalito Dam downstream to the confluence with the Sacramento River
Yuba River	Englebright Lake downstream to the confluence with the Feather River
Bear River	Camp Far West Reservoir downstream to the confluence with the Feather River
American River	Nimbus Dam downstream to the confluence with the Sacramento River
Mokelumne River	Camanche Reservoir downstream to the Sacramento-San Joaquin Delta, including the Cosumnes River and other tributaries
Calaveras River	New Hogan Lake downstream to the Sacramento-San Joaquin Delta
Stanislaus River	Goodwin Dam downstream to the confluence with the San Joaquin River
Tuolumne River	La Grange Dam downstream to the confluence with the San Joaquin River
Merced River	Crocker-Huffman Dam downstream to the confluence with the San Joaquin River
San Joaquin River	Mendota Pool downstream to Vernalis
Bay-Delta estuary	Includes the Delta (Freeport on the Sacramento River and Vernalis on the San Joaquin River downstream to Chipps Island), Suisun Bay, and San Francisco Bay

TABLE III-7

**MAJOR DOWNSTREAM RESERVOIRS POTENTIALLY
AFFECTED BY CVPIA ACTIONS**

Reservoir	Primary Water Source
Whiskeytown Lake	Trinity River (out-of-basin diversion) and Clear Creek
Shasta Lake	Sacramento River
Lake Oroville	Feather River
Bullards Bar Reservoir	Yuba River
Camp Far West Reservoir	Bear River
Folsom Lake	American River
Camanche Lake	Mokelumne River
New Hogan Lake	Calaveras River
New Melones Reservoir	Stanislaus River
New Don Pedro Reservoir	Tuolumne River
Lake McClure	Merced River
San Luis Reservoir	Sacramento-San Joaquin Delta diversion

represented in the analysis are distributed over a range of habitats potentially affected by CVPIA and restoration actions. Anadromous species specifically identified in the CVPIA are:

- chinook salmon (*Oncorhynchus tshawytscha*), including fall, late fall, winter, and spring runs
- steelhead trout (*Oncorhynchus mykiss*)
- sturgeon (both green sturgeon [*Acipenser medirostris*] and white sturgeon [*A. transmontanus*])
- American shad (*Alosa sapidissima*)
- striped bass (*Morone saxatilis*)

In addition to anadromous species identified in the CVPIA, representative species for the Bay-Delta estuary are:

- delta smelt (*Hypomesus transpacificus*)
- longfin smelt (*Spirinchus thaleichthys*)
- Sacramento splittail (*Pogonichthys macrolepidotus*)

Representative species for reservoirs are:

- spotted bass (*Micropterus punctulatus*)
- largemouth bass (*M. salmoides*)

The geographic distribution of the representative species throughout the study area is shown in Figure III-3. Chinook salmon is the most widely distributed species, occurring in all major rivers and streams, in the Bay-Delta, and in the Pacific Ocean.

Each life stage for a particular species population may be present in specific watershed compartments during specific months. Life stages are discrete developmental phases, such as adult migration, spawning, incubation, and rearing (see Chapter II, Affected Environment). Table III-8 shows the geographic and temporal distribution of each life stage for Sacramento River fall-run chinook salmon. The geographic distribution and monthly occurrence for all species and life stages included in the impact assessment are shown in the tables in Attachment A, Monthly Species Occurrence in Each Watershed Compartment by Life Stage.

ENVIRONMENTAL CONDITIONS

As described earlier, CVPIA actions cause changes in environmental conditions, which in turn lead to benefits or impacts on representative species. Assessment methods consist of relationships between environmental conditions and the potential responses of the representative species. Table III-9 shows the environmental conditions pertinent to each representative species and life stage.

The relationships applied to the eight key environmental conditions assessed in this analysis are described in detail below. Each condition is defined, the important relationships related to it are described, and an example is provided of how the relationships were applied in this analysis. These examples allow the reader to review a sample analysis and a sample of the data used in the analysis, and provides information regarding the sources of the data used in the analysis.

Water Temperature

Mortality, reduced growth, and reduced reproductive success occur when water temperature exceeds the metabolic tolerances of a species and life stage. In the Sacramento and San Joaquin River basins, water temperature is primarily a concern for chinook salmon and steelhead trout (Figures III-4 and III-5). Water temperature affects the survival, growth, reproduction, and migration of individuals. The life stages included in the assessment of temperature effects are adult migrants, spawning and incubation, fry and juvenile rearing, and migrating juveniles.

Water temperature is the primary environmental variable; however, other environmental variables can affect water temperature, including flow, reservoir surface elevation, barriers, water quality, and physical habitat. Each of these must be considered in the evaluation of water temperature conditions. Habitat restoration actions, changes in reservoir operations (including operation of multilevel release structures), and changes in flows can affect water temperatures in the rivers of the study area (Figure III-6).

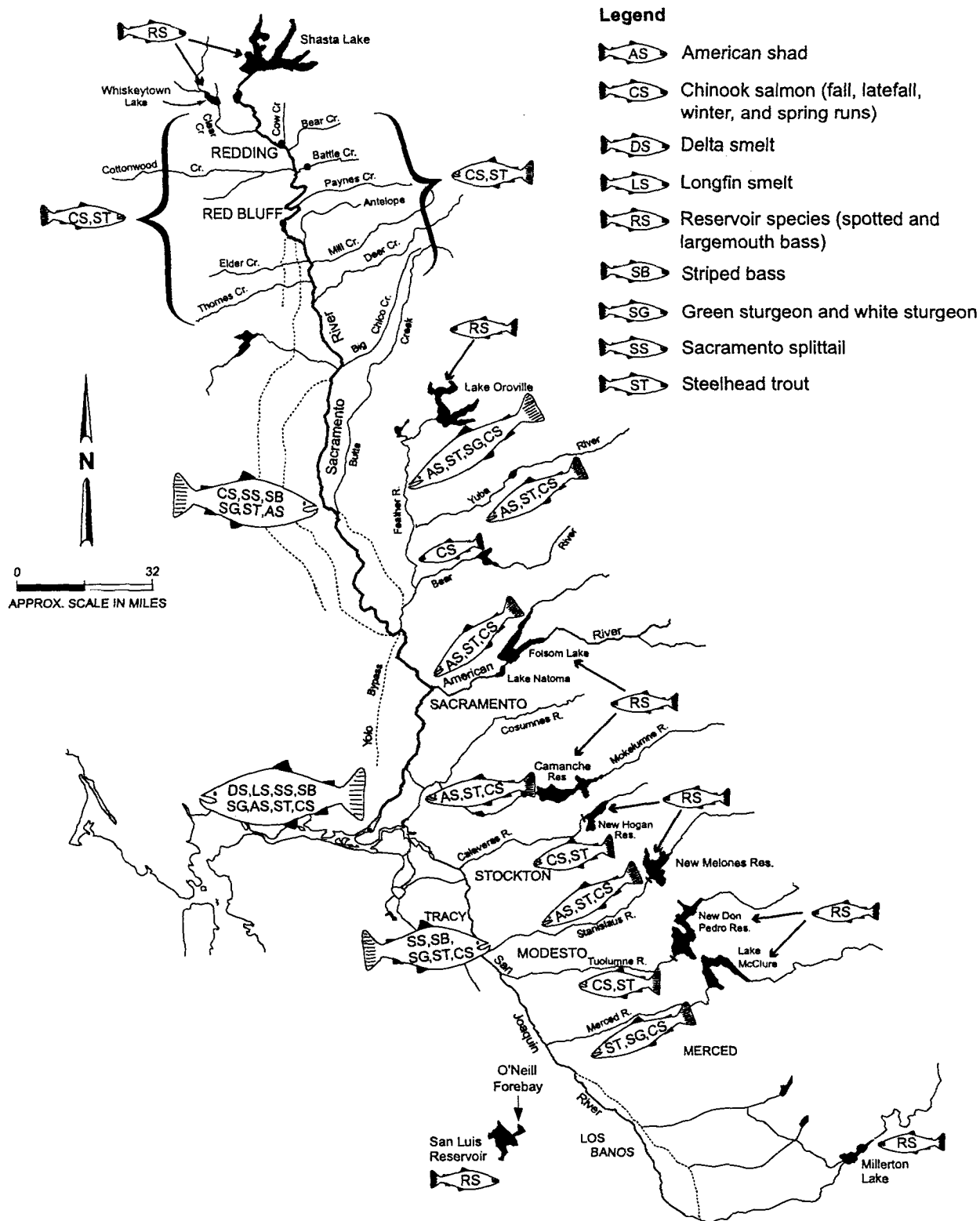


FIGURE III-3

POTENTIAL AND EXISTING DISTRIBUTION OF FISH SPECIES INCLUDED IN THE PEIS

TABLE III-8

GEOGRAPHIC OCCURRENCE BY LIFE STAGE FOR FALL-RUN CHINOOK SALMON

		October			November			December			January			February			March			April		May		June		July		Aug		Sept	
Watershed Compartment	Sacramento River	●	●	○	○	●	●	○	○	●	●	○	○	●	○	○	●	●	○	○	●	●	○	○	○	○	○	○	○	○	
	Clear Creek	●	●		○	●	●	○	○	●	●	○	○	●	○	○	●	●	○	○	○	○	○	○	○	○	○	○	○	○	
	Minor tributaries	●	●		○	●	●		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
	Feather River	●	●	○	○	●	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
	Yuba River	●	●		○	●	●		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
	Bear River	●	●		○	●	●		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
	American River	●	●		○	●	●		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
	Mokelumne River	●	○		○	●	●		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
	Calaveras River	●	○		○	●	●		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	Stanislaus River	●	●			●	●			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Tuolumne River	●	●		○	●	●			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
Merced River	●	●		○	●	●			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
San Joaquin River	●			○	●			○				○	○	○			○	○	○	○	○	○	○	○	○	○	○	○	○	○	
Bay-Delta	●			○	●				○					○			○	○	○	○	○	○	○	○	○	○	○	○	○	○	

LEGEND:
● = indicates primary occurrence.
○ = indicates minor or potential occurrence.

LEGEND:
 ● = Indicates primary occurrence.
 ○ = Indicates minor or potential occurrence.

TABLE III-9
ENVIRONMENTAL CONDITIONS INCLUDED IN THE IMPACT ASSESSMENT FOR
EACH REPRESENTATIVE FISH SPECIES BY LIFE STAGE

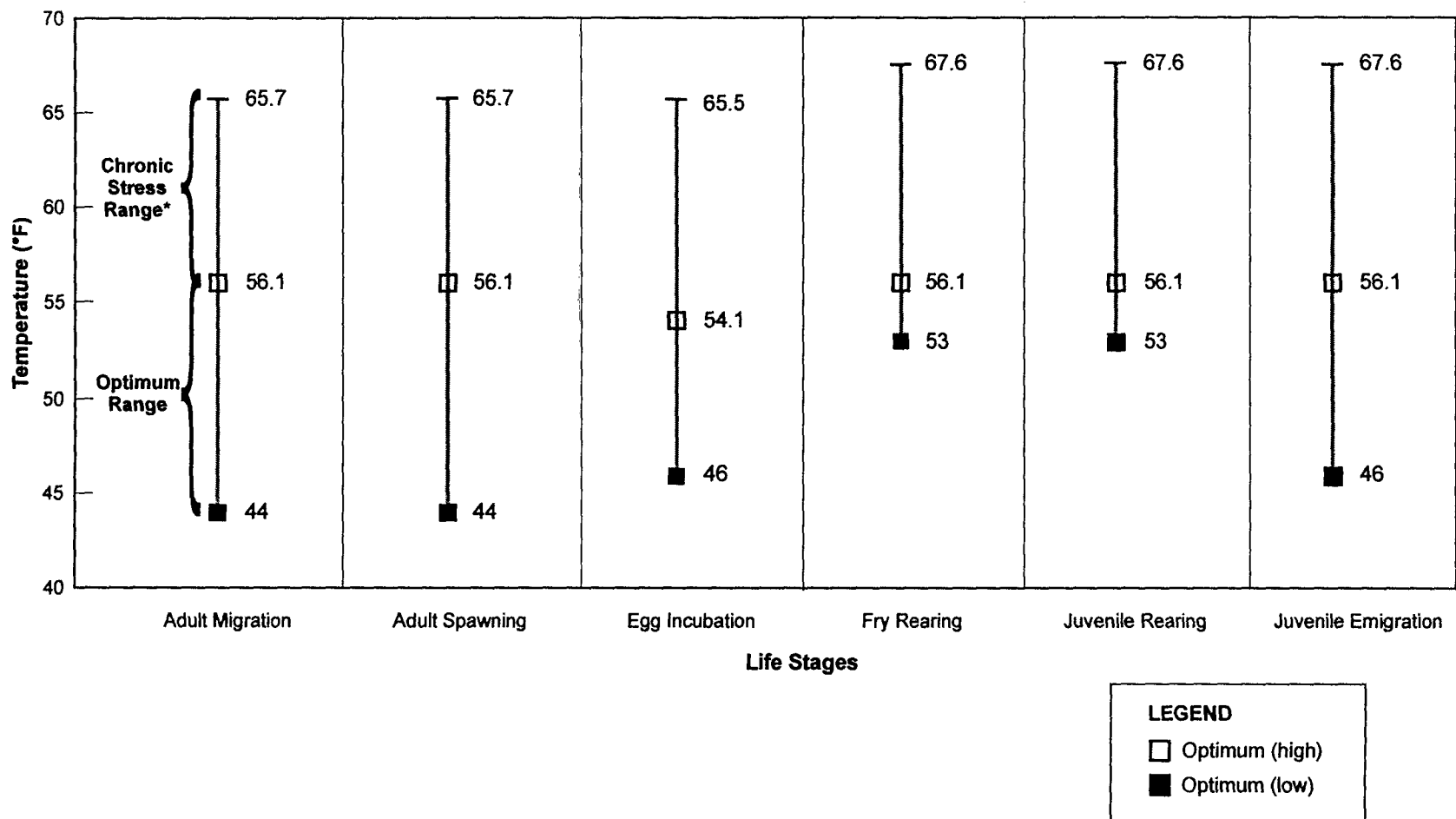
Environmental Conditions	Chinook Salmon (Fall, Late Fall, Winter, Spring Runs)					Steelhead Trout					Sturgeon				American Shad				Striped Bass				Delta Smelt			Longfin Smelt			Sacramento Spittail				Spottmouth Bass			Large mouth Bass
	Adult Migration/Holding	Spawning/Incubation	Fry Rearing	Juvenile Rearing	Juvenile Migration	Adult Migration/Holding	Spawning/Incubation	Fry Rearing	Juvenile Rearing	Juvenile Migration	Adult Migration	Spawning/Incubation	Larval Rearing	Juvenile/Adult Rearing	Juvenile Migration	Adult Migration	Spawning/Incubation	Larval Rearing	Juvenile/Adult Rearing	Juvenile Migration	Spawning/Incubation	Larval Rearing	Juvenile/Adult Rearing	Spawning/Incubation	Larval Rearing	Juvenile/Adult Rearing	Juvenile Migration	Spawning/Incubation	Juvenile/Adult Rearing	Spawning/Incubation	Juvenile/Adult Rearing					
Water temperature	●	●	●	●	○	●	●	●	●	○																										
Diversiion			○	○	●			○	○	●				○	●																					
Change in water surface level		●	●	●	○		●	●	●	○					○																					
Pollutants		●	●	●	○		●	●	●	○				○																						
Predation				○	●																															
Movement	●		○	○	●	●		○	○	●																										
Habitat quantity and quality		●	●	●	○		●	●	●	○				○																						
Food web support			●		○			●	○	○				○																						

LEGEND:

○ = Ecosystem function considered for life stage, but specific responses are incorporated in the response by other life stages.

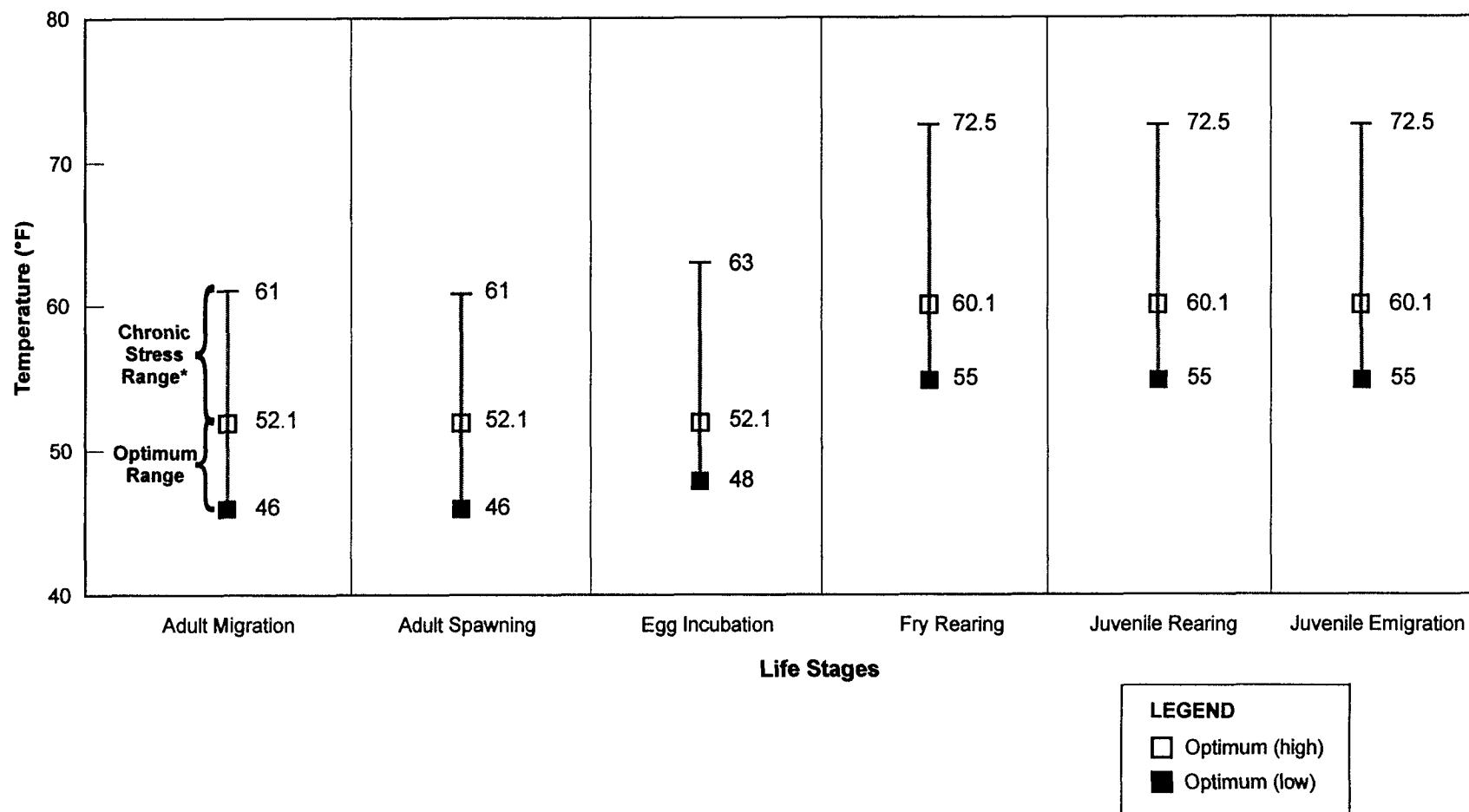
● = Ecosystem function is assessed for life stage.

LEGEND:
 ○ = Ecosystem function considered for life stage, but specific responses are incorporated in the response by other life stages.
 ● = Ecosystem function is assessed for life stage.



* Chronic stress is indicated by factors such as reduced growth or increased incidence of disease that may not result in the death of an organism. Exposure to water temperature at the upper end of the chronic stress range or exposure to temperatures in the chronic stress range over long periods increases the likelihood of death of an organism.

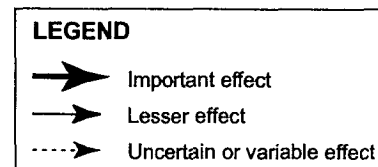
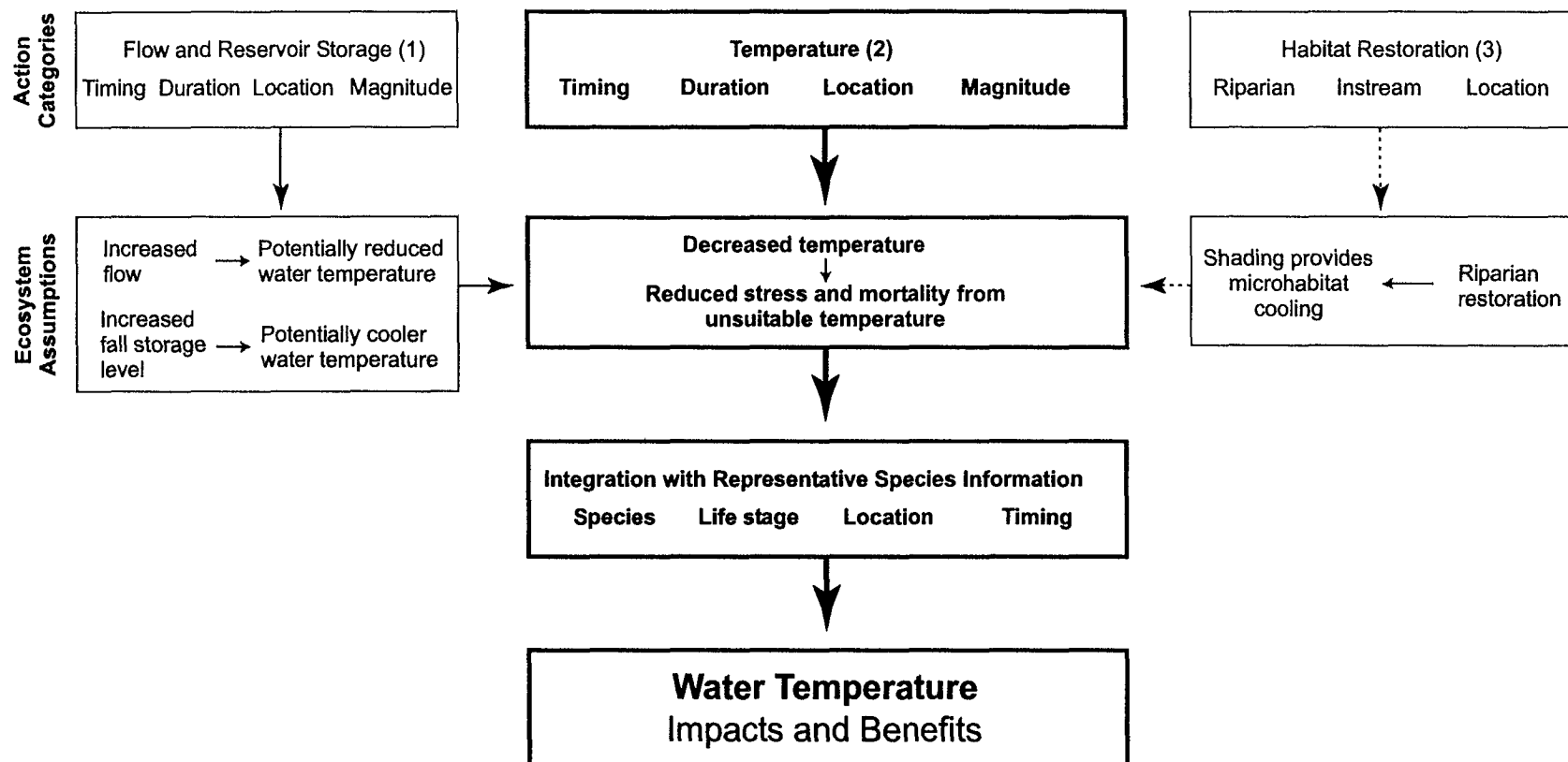
FIGURE III-4
TEMPERATURE-MORTALITY RELATIONSHIPS FOR CHINOOK SALMON



* Chronic stress is indicated by factors such as reduced growth or increased incidence of disease that may not result in the death of an organism. Exposure to water temperature at the upper end of the chronic stress range or exposure to temperatures in the chronic stress range over long periods increases the likelihood of death of an organism.

FIGURE III-5

TEMPERATURE-MORTALITY RELATIONSHIPS FOR STEELHEAD TROUT



SOURCES:

- (1) Fisheries Technical Appendix Attachment B; Surface Water Supplies and Facilities Operations Technical Appendix
- (2) Fisheries Technical Appendix Attachment B
- (3) PEIS Attachment F

FIGURE III-6

PROPOSED ACTIONS AFFECTING WATER TEMPERATURE CONDITIONS

Specific relationships are included in the assessment where information is available. Simulated water temperatures for each PEIS alternative are generated by Reclamation's monthly temperature models for Clear Creek and the Sacramento, Feather, American, and Stanislaus rivers. The water temperature models use flow and reservoir data simulated by PROSIM and SANJASM (see the Surface Water Supplies and Facilities Operations Technical Appendix) for the 69-year period of record (water years 1922-1990) to estimate average monthly water temperatures. For each river, the water temperature models compute river water temperature at various locations (i.e., nodes) downstream from major reservoirs. Nodes located near the Anderson-Cottonwood Irrigation District (ACID) diversion, Jelly's Ferry, and Vina are used in the assessment of Sacramento River water temperature effects; the node near Igo is used for Clear Creek; nodes upstream and downstream of the Thermalito Afterbay discharge are used for the Feather River; the node near Sunrise is used for the American River; and nodes located near Knight's Ferry and Oakdale are used for the Stanislaus River. Simulated water temperatures were not available for other Sacramento-San Joaquin Basin rivers and streams.

Temperature changes that are within the chronic-stress range for a species are assumed to cause changes in mortality. The optimal and chronic-stress temperature ranges are unique for each life stage of chinook salmon and steelhead trout (Figures III-4 and III-5). The upper temperature is considered lethal, but generally exceeds the lethal temperature identified in the available literature (Chambers, 1956; Raleigh et al., 1986; Leidy and Li, 1987; Reiser and Bjornn, 1987; Rich, 1987; Bell, 1990; DFG, 1991; McEwan and Nelson, 1991). Wider temperature ranges were used because of the potential for variability in simulated temperature data, because monthly rather than daily or hourly temperature values are being used, and because of uncertainties that are part of the temperature simulation models.

A separate set of assessment methods is applied to rivers where simulated water temperature data are not available and to evaluate the effects of factors not accounted for in the water temperature models. The following assumptions are applied based on available information:

- Riparian restoration actions reduce water temperature and improve temperature conditions.
- Increased reservoir surface elevation during August through October reduces water temperature in the river reaches below the reservoir.
- Increased river flow from late April through October reduces water temperature.

Example Water Temperature Analysis: Alternative 1, American River, Fall-Run Chinook Salmon - Temperature Model Data Available. For this example analysis, water temperature effects on fall-run chinook salmon in the American River under Alternative 1 are determined by comparing water temperature conditions under Alternative 1 with those under the No-Action Alternative. For this example, monthly temperature data from Reclamation's water temperature model are available.

Data Sources. Average monthly water temperature is simulated by Reclamation's water temperature model (as discussed in Attachment B, Fish Habitat Water Quality Technical Information). The 69-year simulation of monthly water temperature from Reclamation's model is provided in Attachment B. Figure III-7 presents a sample of the model results in the manner used for the analysis. The figure shows the model results for the American River at Fair Oaks for the

No-Action Alternative and Alternative 1 in graphic form. One graph is provided for each month of the year: The first graph presents all 69 modeled Octobers, the second all Novembers, and so on.

In these graphs, the months under the No-Action Alternative with the lowest temperatures are on the left and those with the highest temperatures are on the right. The bars present the difference between No-Action Alternative and Alternative 1 data, measured against the right-hand scale on the graph.

For rivers where simulated water temperature data are not available, flow and reservoir elevation provide an indication of potential water temperature effects.

Example Temperature Analysis: Alternative 1, American River, Fall-Run Chinook Salmon - No Temperature Model Data Available. For this example, no simulated temperature data are assumed to exist for the American River. The methodology used for rivers where no temperature data exist is used here to demonstrate the process and compare the results with those of the previous example.

Under Alternative 1, for example, increased water temperature in the American River during June through September (Figure III-7) is caused by a 20-percent to 40-percent reduction in flow during those months. During October of most years under Alternative 1, increased river flow (20 percent to 40 percent) cools water temperatures in the river relative to conditions under the No-Action Alternative. The response of water temperature to flow is consistent with the assumption that increased flow during April through October is indicative of reduced water temperature (Figure III-6).

The relationship between flow and water temperature does not always hold during October and November. During October and November, Folsom Reservoir storage and American River flow increase under Alternative 1 compared to conditions under the No-Action Alternative. The assumed relationship (Figure III-6) would be a reduction in water temperature, but the opposite condition is indicated by the simulation for October (for years when water temperature is less than 58 degrees Fahrenheit) and November (for all years). This increase in water temperature is attributable to the release of reservoir water that is warmer than the water in the river. This occurs because ambient air temperature begins to cool during October and November but reservoir water cools more slowly (depending on the weather during the preceding months and reservoir volume). The use of a multilevel release structures could prevent this temperature increase by permitting the release of cool water from deeper reservoir strata. Increased reservoir storage (as occurs under Alternative 1) and management of the coolwater pool could increase the volume of cool water available for discharge during October and November.

Step 1: Assessment of Changes in Temperature during Months when Species Are Present in the American River. In Figure III-7, water temperatures under Alternative 1 increase compared to those under the No-Action Alternative from June through September and in November and decrease compared to those under the No-Action Alternative during February and March. During April and May, no clear patterns of temperature differences between Alternative 1 and the No-Action Alternative are apparent. During October, water temperature increases during years with relatively low water temperatures and decreases during years with relatively high temperatures.

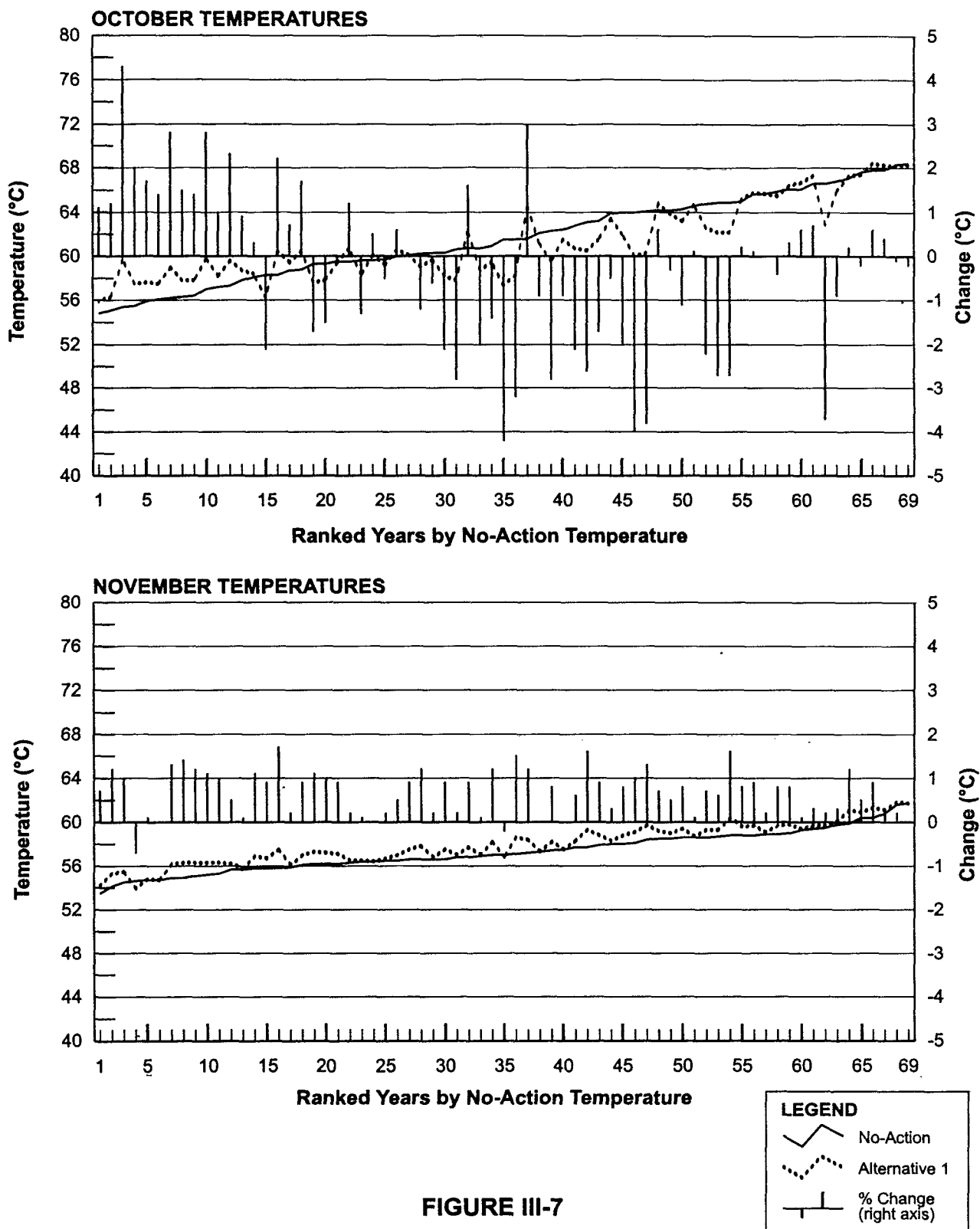


FIGURE III-7

**SIMULATED TEMPERATURE OF THE AMERICAN RIVER AT CORDOVA
FOR ALTERNATIVE 1 AND THE NO-ACTION ALTERNATIVE**

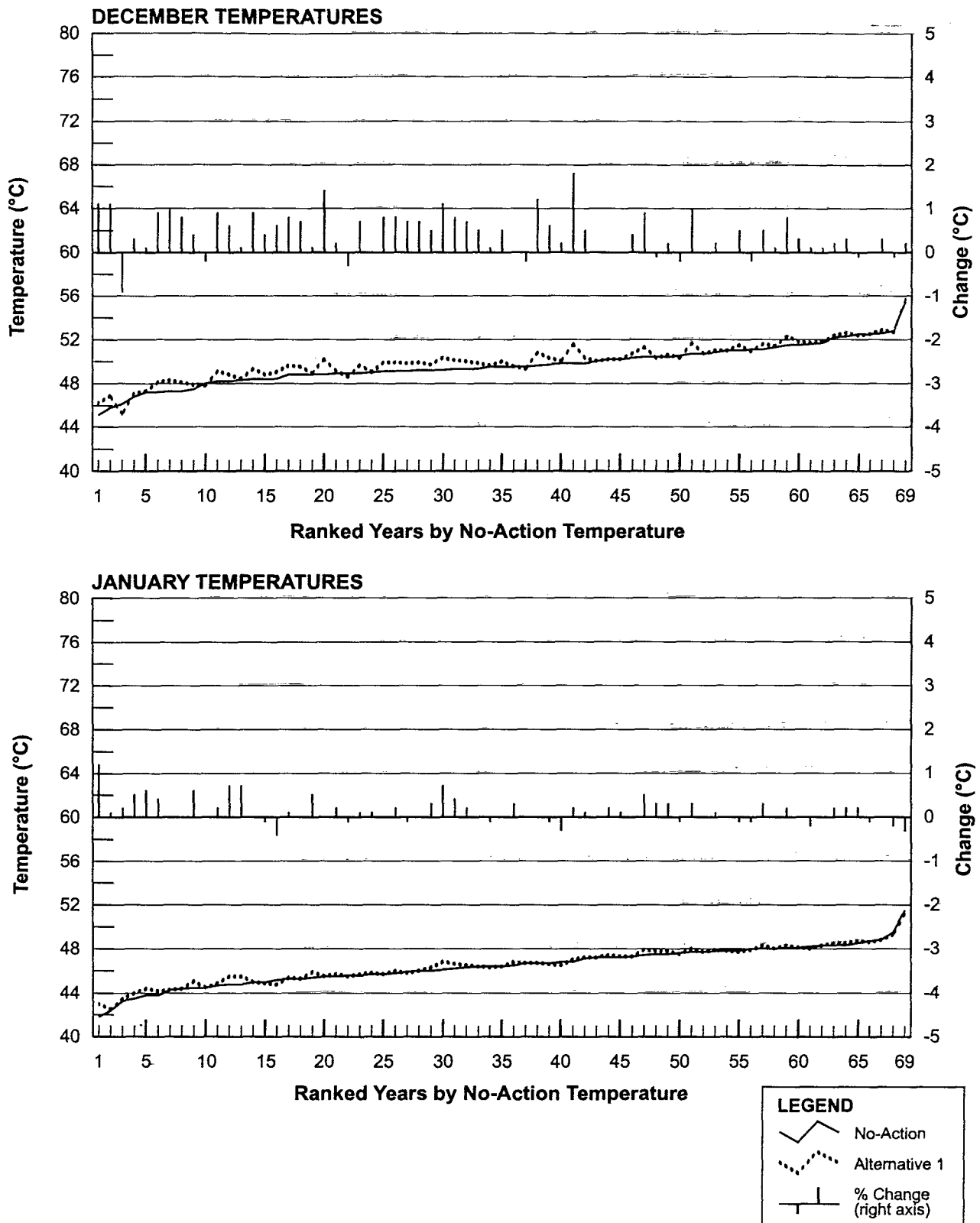


FIGURE III-7. CONTINUED

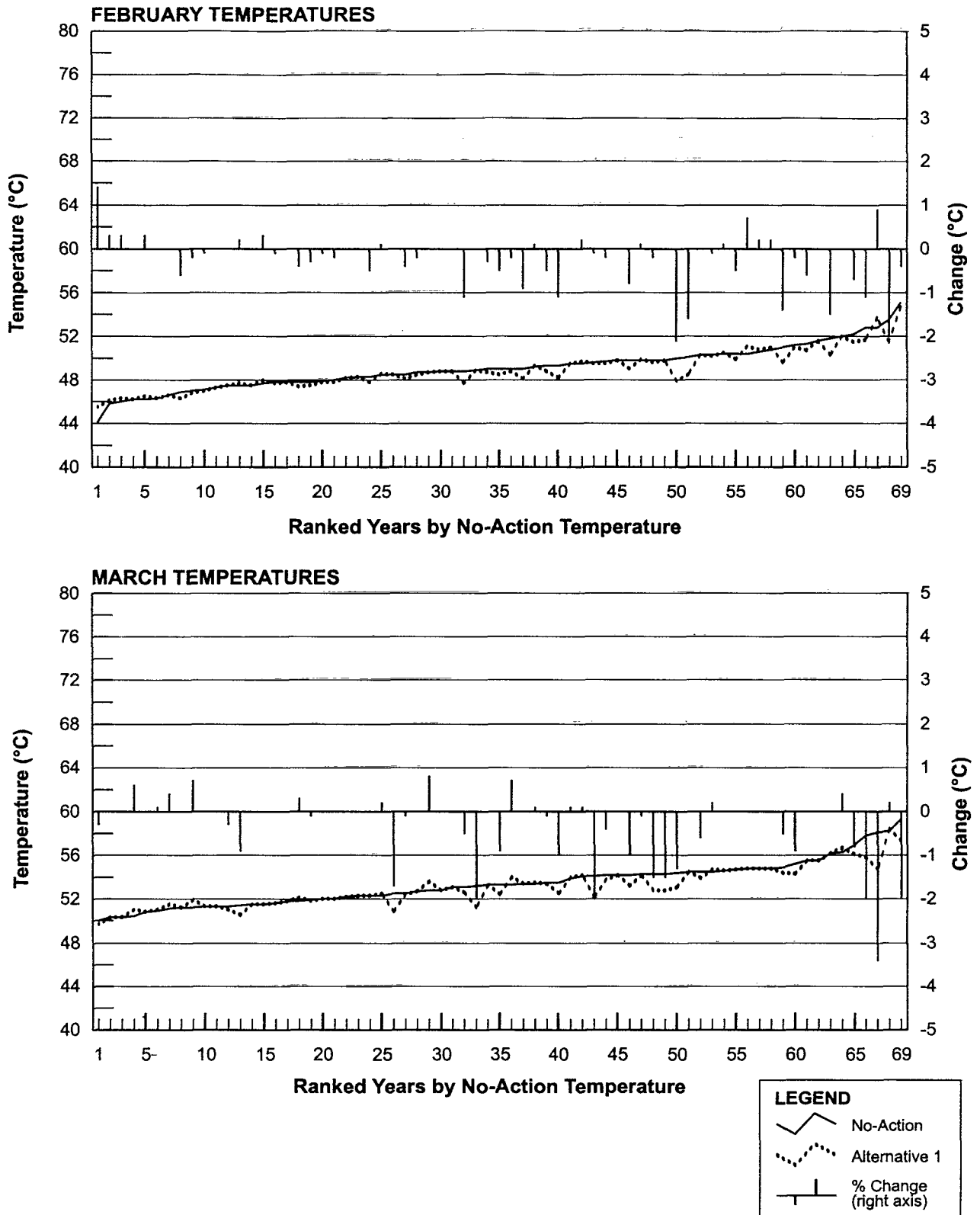


FIGURE III-7. CONTINUED

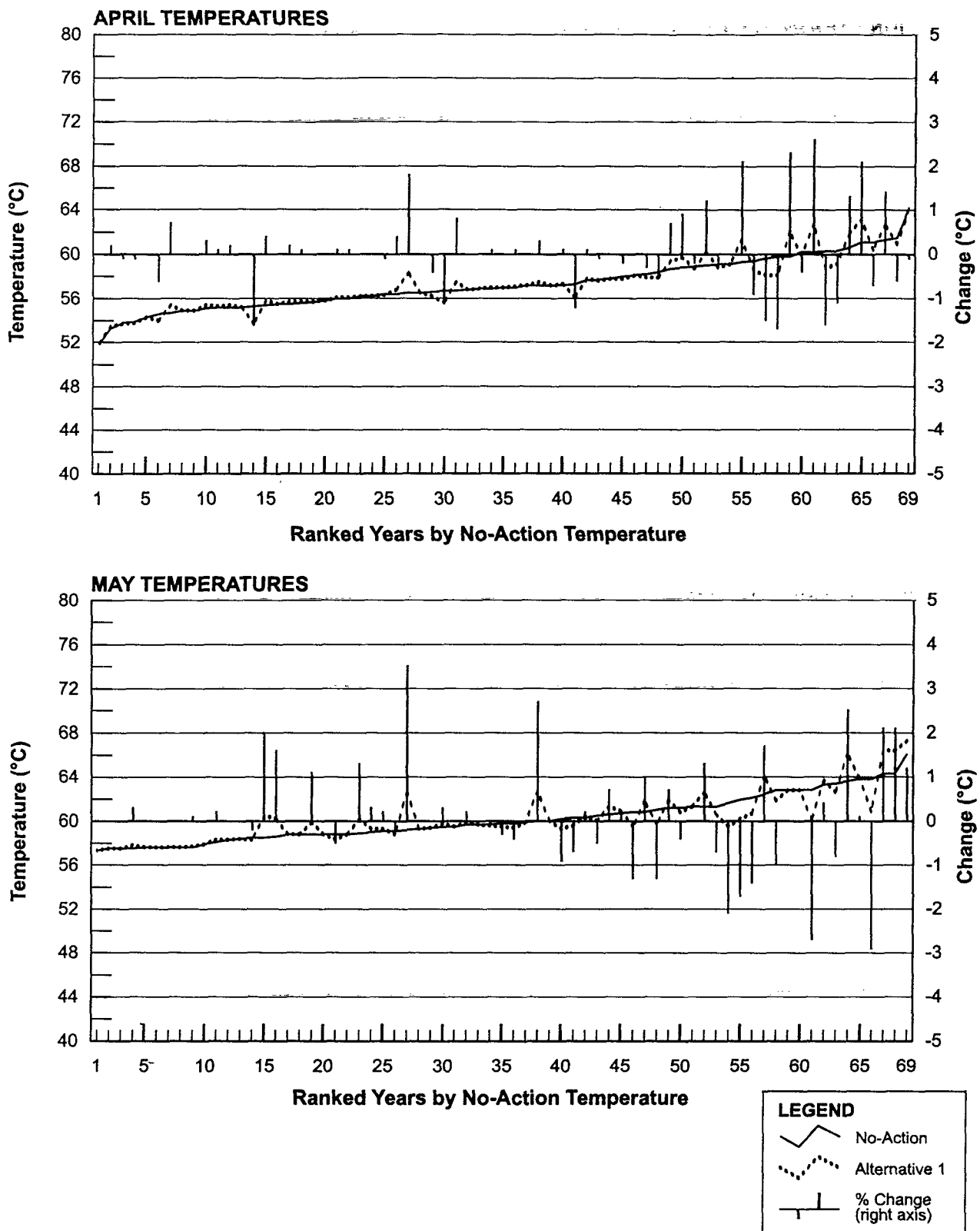


FIGURE III-7. CONTINUED

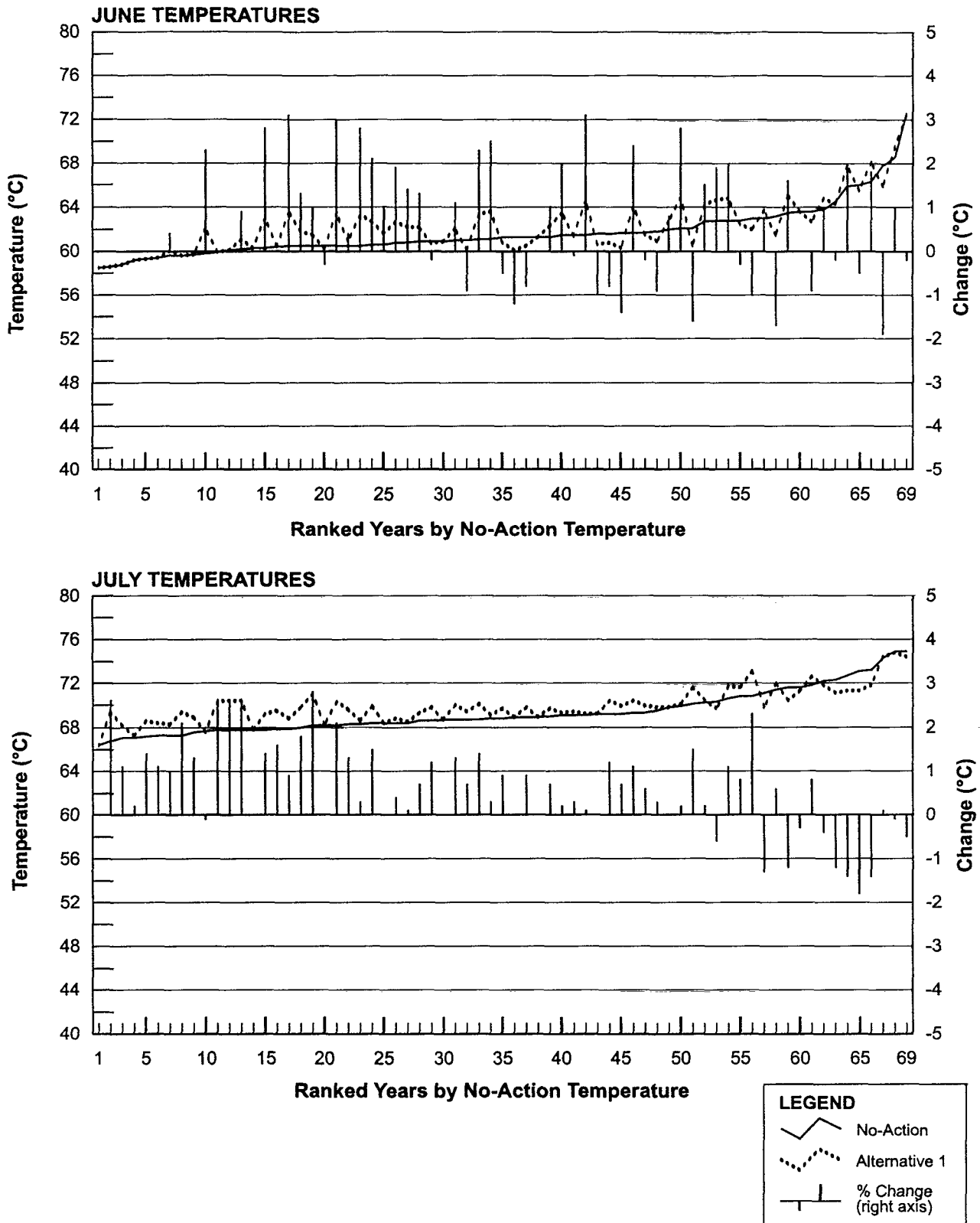


FIGURE III-7. CONTINUED

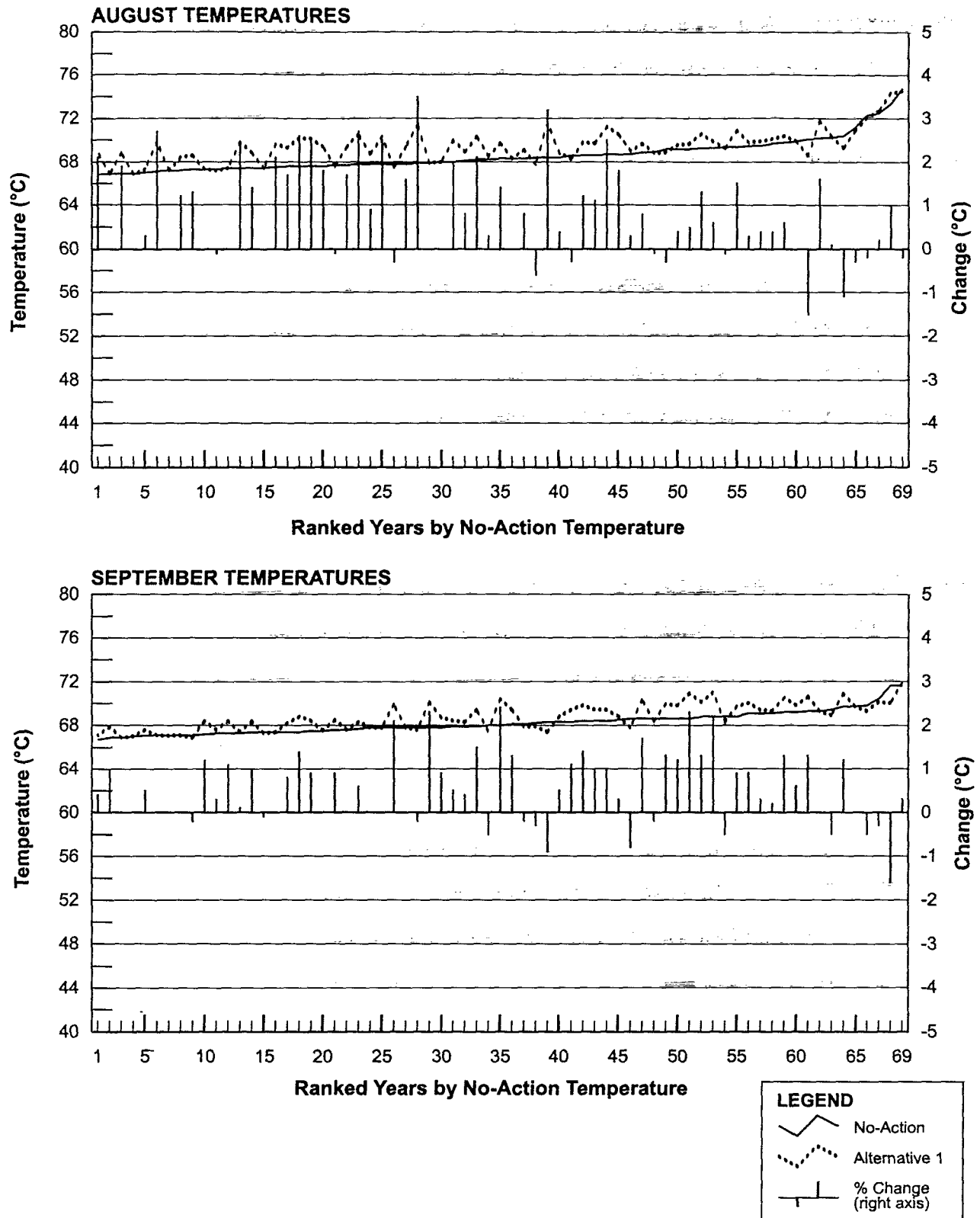


FIGURE III-7. CONTINUED

As indicated in Table A-1 of Attachment A, chinook salmon are present in the American River during the following life stages and months:

- adult migration and holding - September, October, and November;
- spawning and incubation - October, November, December, and January;
- fry rearing - January, February, and March;
- juvenile rearing - March, April, and May; and
- juvenile migration - February, March, April, and May.

The assessment of water temperature effects on fry and juvenile migrations are included in the assessment for the rearing life stages (Table III-9). Water temperatures during June, July, and August are not considered in the assessment of water temperature impacts for fall-run chinook salmon in the American River because relatively few individuals of this species are present in the American River during these months.

Step 2: Assessment of Biological Effects of Monthly Temperature Changes.

Water temperatures in the American River remain within the optimal range for those life stages present in the river during December, January, February, and March (Figure III-4). As noted above, water temperatures in the American River during April and May are not clearly different under Alternative 1 compared to the No-Action Alternative (Figure III-7). The analysis, therefore, focuses on water temperatures during September, October, and November. The life stages affected by water temperature during these months are adult migration, spawning, and incubation.

During September, adult chinook salmon are present in the American River. Although water temperature would increase under Alternative 1 compared to conditions under the No-Action Alternative (Figure III-7), September water temperature conditions exceed the chronic-stress range (Figure III-4) under both the No-Action Alternative and Alternative 1. As water temperature increases from the optimum range through the chronic-stress range, adverse effects on fish increase. Because temperatures above the chronic-stress range are considered lethal, further water temperature increases would not result in increased adverse effects on chinook salmon.

Adult migration, spawning, and incubation take place in October. During most years, water temperature in October would be lower under Alternative 1 than under the No-Action Alternative (Figure III-7). The reduced water temperature would benefit adult migration, spawning, and incubation life stages. However, during some years, water temperature would reach the chronic-stress range for egg incubation, which could contribute to reduced survival (Figure III-4).

Adult migration, spawning, and incubation also take place during November. Water temperatures would be higher during November under Alternative 1 than under the No-Action Alternative (Figure III-7), causing adverse effects (Figure III-4).

Step 3: Determining Impacts. No specific significance thresholds are used in this analysis. Instead, an adverse temperature impact is assigned in a particular river for particular species and life stages if all of the following criteria are met:

- water temperature in the river under an alternative increases compared to conditions under the No-Action Alternative,

- the temperature change occurs within the chronic-stress range of the species life stage,
- the temperature change occurs during months when a substantial proportion of the life stage is present in the river, and
- the change in temperature is not offset by physical improvements (such as riparian restoration) not captured in the modeling but that may reduce temperatures.

Step 4: Summary of Effects by Species and Overall Summary. In summary, water temperature conditions under Alternative 1 would adversely affect a substantial proportion of the adult, spawning, and incubation life stages of fall-run chinook salmon in the American River.

Although an adverse water temperature impact is identified, an overall benefit is indicated for fall-run chinook salmon in the American River. This assessment is made because some of the CVPIA Actions implemented under Alternative 1 (e.g., habitat restoration, fish screen improvements) could not be modeled but would result in benefits for fall-run chinook. In addition, the water temperature effects in the American River during fall are based on the modeling assumption that no new facilities would be constructed. The construction of a multilevel release structure at Folsom Dam, as identified in the CVPIA, could permit the release of cooler water during fall than was indicated by the simulation. This structure may allow the adverse impact of increased water temperature to be avoided, increasing the benefits of the other actions.

Diversion

Diversions cause fish mortality through entrainment (removal from the ecosystem), impingement on fish screens or other structures associated with the diversion facility, abrasion, stress, and increased predation. In the Sacramento and San Joaquin River regions, diversion is a concern for all fish species (except reservoir populations) included in the impact assessment (Table III-9). The life stages affected by diversions are species dependent. For example, chinook salmon are most affected during fry and juvenile downstream migrations. Other species suffer losses to diversions most of their life cycle and may be especially vulnerable during the larval life stage (e.g., striped bass, delta smelt, and longfin smelt).

The factors considered in assessing diversion conditions are diversion volume and fish screen design, flow (including estuarine salinity and Delta channel flow), and species interactions such as predation. Other interrelated factors affect vulnerability to diversions, but they are not considered in this assessment of diversion conditions (e.g., water temperature, physical habitat, and water quality). CVPIA actions related to flow, diversion, fish screen structures, and species interactions will affect diversion conditions in rivers and the Bay-Delta estuary (Figure III-8).

The methods for assessing diversion include the following assumptions:

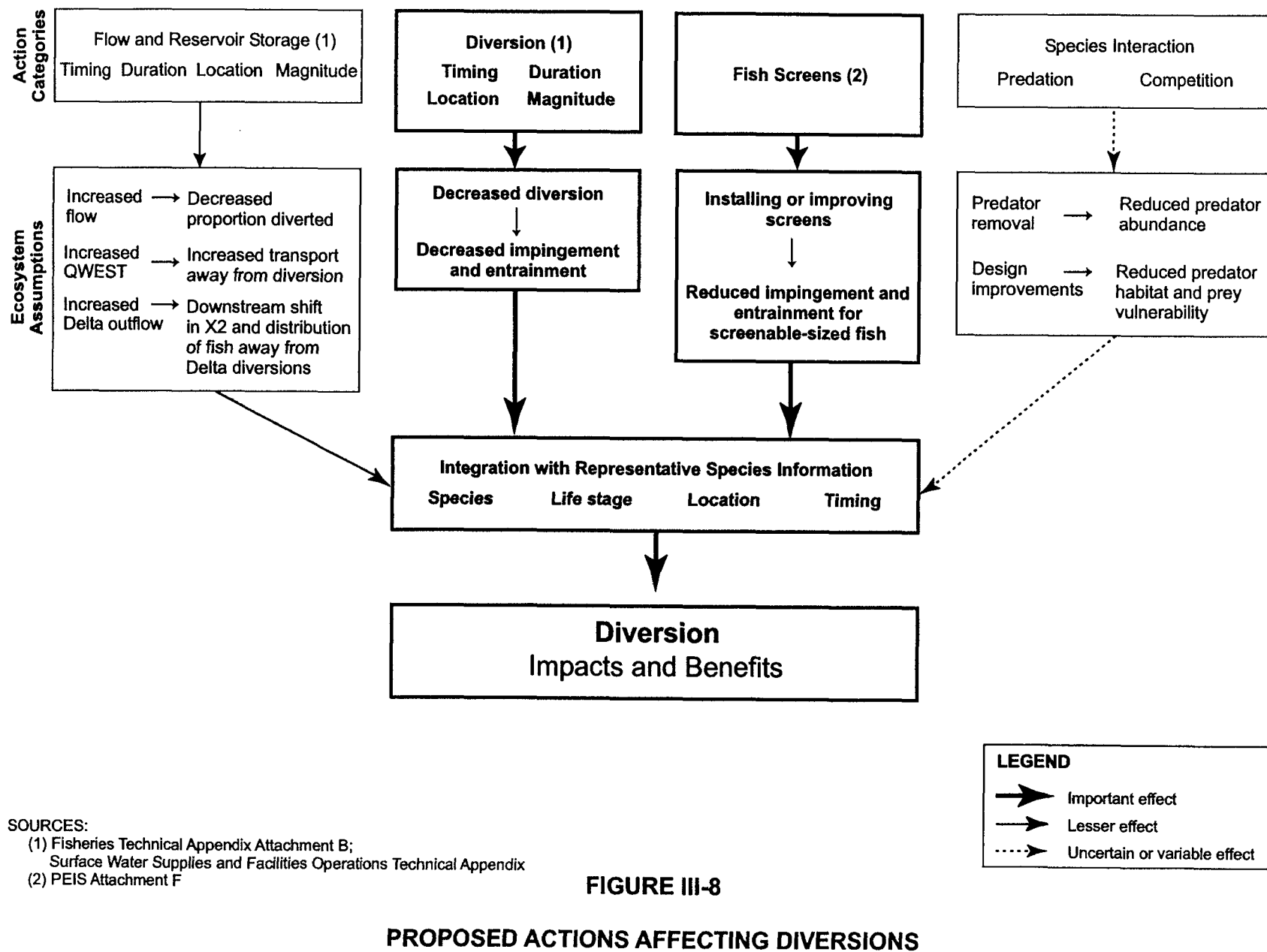


FIGURE III-8

PROPOSED ACTIONS AFFECTING DIVERSIONS

- Fish screens and fish screen improvements reduce entrainment and impingement and reduce diversion loss during periods when target species are vulnerable to diversions.
- An increase in diversion volumes or in the proportion of flow diverted increases diversion loss during periods when target species are vulnerable to diversions.
- Increased diversion from the Delta increases net channel flow toward diversion facilities and increases diversion loss.
- Upstream shift of the 2 ppt estuarine salinity increases diversion-related losses at Delta diversion facilities during periods when target species are vulnerable to diversions.
- Diversion facilities provide habitat and increased feeding opportunities for predatory fish that increase diversion-related losses.

CVPIA actions to construct and improve fish screens would improve diversion conditions and reduce the loss of screenable species and life stages. Fish screens would benefit most life stages of each of the representative species but would provide minimal protection for planktonic eggs and larvae. American shad and striped bass spawn planktonic eggs that are small and would pass through the fish screens. American shad, striped bass, delta smelt, and longfin smelt have planktonic larvae that would either pass through the screens or, because larvae are weak swimmers, would be impinged on the screen surface.

The proportion of flow diverted and net channel flow toward Delta diversion facilities are assumed to affect all life stages of all species vulnerable to entrainment. Adult striped bass, chinook salmon, green sturgeon and white sturgeon, and American shad are assumed minimally affected by entrainment in diversions. Adult delta smelt, longfin smelt, and splittail are vulnerable to entrainment in Delta diversions (see Chapter II, Affected Environment). Increases in the upstream location of the 2 ppt estuarine salinity line are assumed to increase the vulnerability of juvenile striped bass and delta smelt to entrainment. Predation affects juveniles of all species and adult delta smelt, longfin smelt, and Sacramento splittail.

The assumptions used in this analysis that diversion losses increase when the proportion of flow diverted increases, when net channel flow toward Delta diversion facilities increases, and when estuarine salinity shifts upstream are not strongly supported by research (Vogel, 1995; DWR and Reclamation, 1993). Some studies have indicated that increasing diversion does not necessarily increase entrainment. Entrainment, however, occurs only when water is diverted and when entrained species have moved within the influence of the diversion. An upstream shift in estuarine salinity and net channel flow toward diversions may increase the movement of Delta species within the influence of diversions. The change in loss rate attributable to increased diversion, net flow toward diversions, and shift in estuarine salinity is dependent on many factors (e.g., species behavior, diversion location, diversion design) that are beyond the scope of this programmatic analysis. The assumptions regarding diversions are being used in this analysis because they are conservative and ensure that potential adverse effects and benefits are identified.

Monthly average diversion and flow are simulated for the 69-year period of record (the hydrology from water years 1922 through 1990) for rivers in the study area, including the Sacramento,

Feather, Yuba, American, Mokelumne, Calaveras, Merced, Tuolumne, Stanislaus, and the San Joaquin rivers (see the Surface Water Supplies and Facilities Operations Technical Appendix).

Diversion facilities provide habitat and increased feeding opportunity for predatory fish (DFG, 1987; Vogel, 1995). CVPIA actions that implement programs to remove predators and change facility design to reduce prey vulnerability reduce loss of the representative species to diversion.

Example Diversion Analysis: Alternative 1, American River, Fall-Run Chinook Salmon. For this example analysis, diversion effects on fall-run chinook salmon in the American River under Alternative 1 are determined by comparing diversion conditions under Alternative 1 with those under the No-Action Alternative.

Data Sources. Flows and diversions are simulated for each PEIS alternative by Reclamation's monthly operations models PROSIM and SANJASM (see the Surface Water Supplies and Facilities Operations Technical Appendix). Individual diversions are consolidated in the simulation except for selected large diversions.

Monthly average channel flows, diversions, and estuarine salinity are simulated for the Sacramento-San Joaquin Delta (see Attachment B, Fish Habitat Water Quality Technical Information, and the Surface Water Supplies and Facilities Operations Technical Appendix). An indication of the movement of net channel flow toward diversion facilities is provided by simulating the movement of water originating from specific areas of the Delta.

In addition, Alternative 1 specifies improving existing fish screens and installing new fish screens on many watersheds. CVPIA actions that affect diversion facilities are qualitatively described in PEIS Attachment F.

Step 1: Assessment of Changes in Diversion during Months when Species Are Present. As shown in Figure III-9, the volume diverted for all months under Alternative 1 is the same as the volume diverted under the No-Action Alternative. Thus, no changes in entrainment and impingement attributable to diversion volume are expected.

However, Alternative 1 specifies improving existing fish screens and installing new fish screens on American River diversions. Fish screens would clearly reduce entrainment and impingement for screenable-sized individuals.

As indicated in Table A-1 of Attachment A, chinook salmon are present in the American River during the life stages and months described under Water Temperature. The assessment of diversion effects on fry and juvenile rearing are included in the assessment for juvenile migration (Table III-9). Diversion during June through January is not considered in the assessment of diversion impacts for fall-run chinook salmon in the American River because potentially affected life stages either are not present or are present only in small numbers.

Step 2: Assessment of Biological Effects of Diversion by Month. Because the volume of flow diverted under Alternative 1 would not change from that under the No-Action Alternative, only the effects of fish screens are considered in the assessment of diversion. Properly designed, installed, and functioning fish screens would reduce entrainment and impingement of rearing and migrating fry and juveniles at diversion facilities.

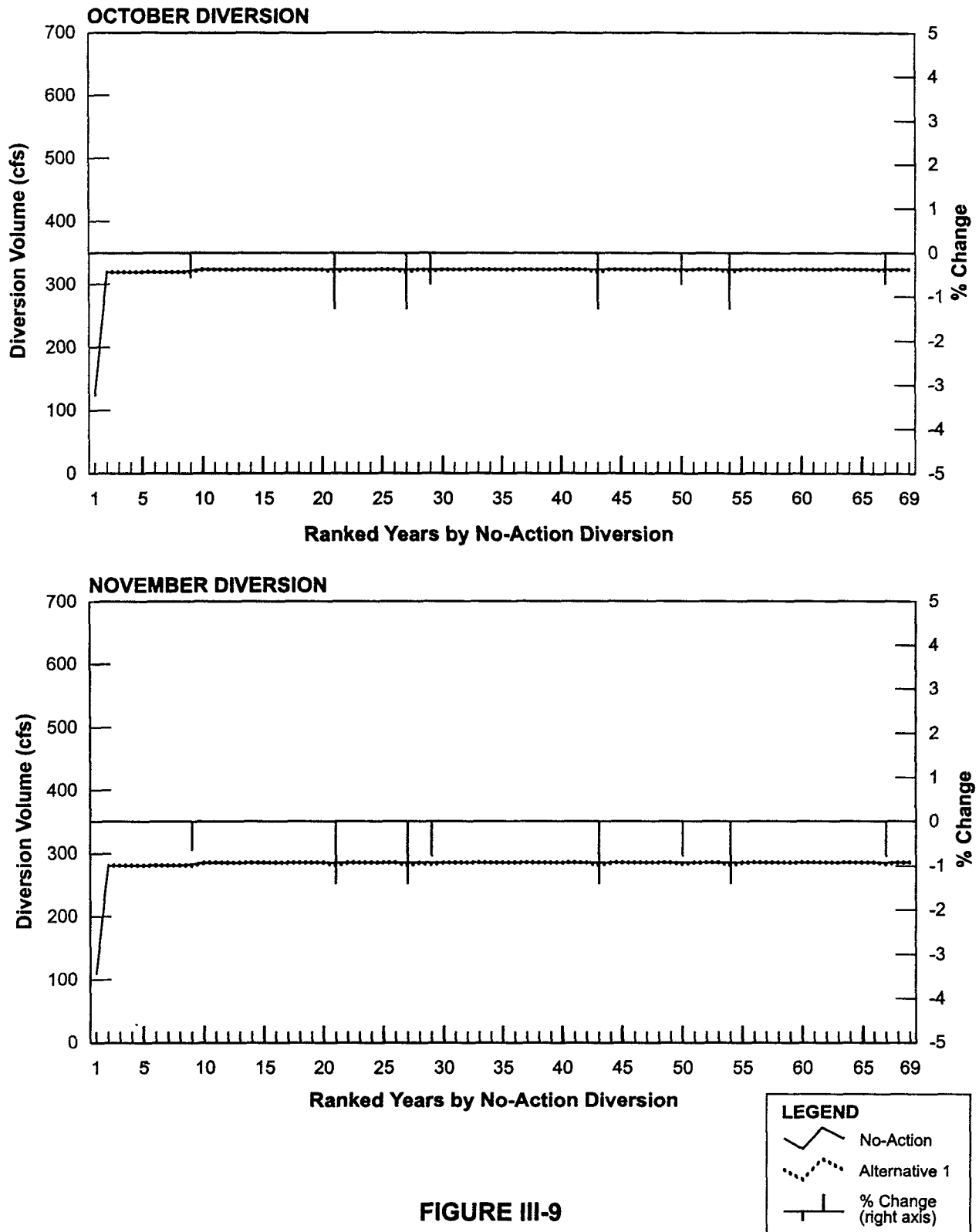


FIGURE III-9

**SIMULATED AMERICAN RIVER DIVERSIONS
FOR ALTERNATIVE 1 AND THE NO-ACTION ALTERNATIVE**

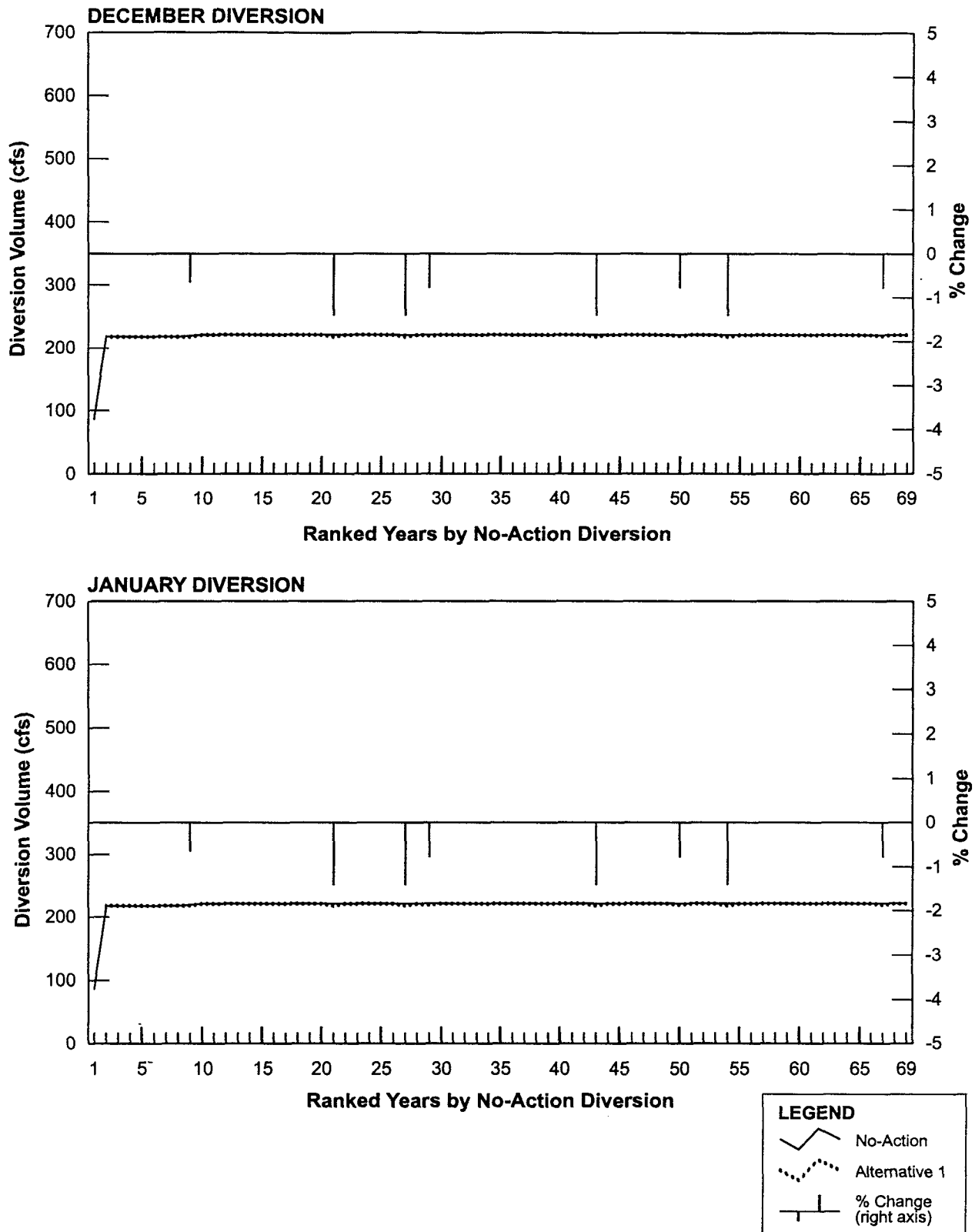


FIGURE III-9. CONTINUED

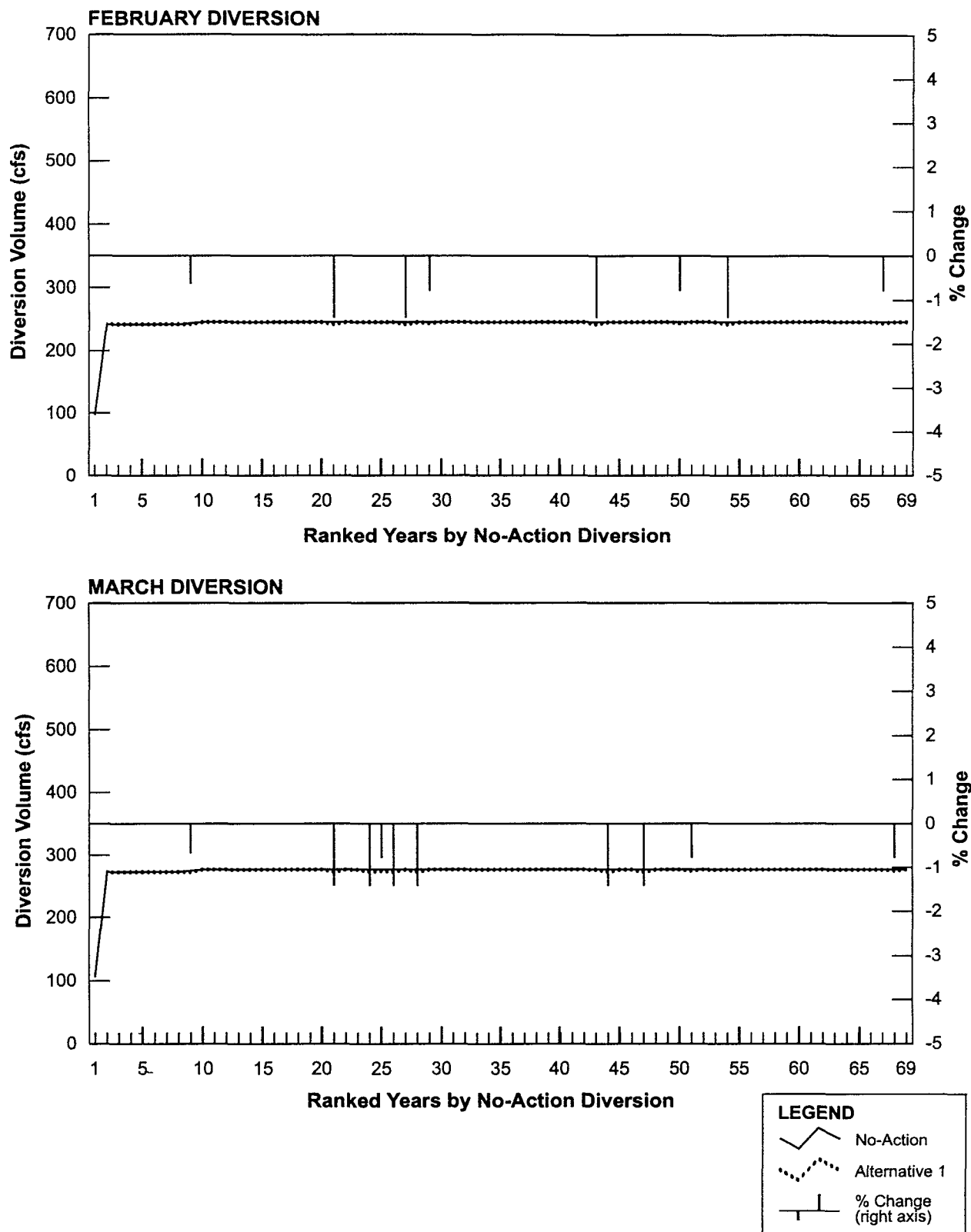


FIGURE III-9. CONTINUED

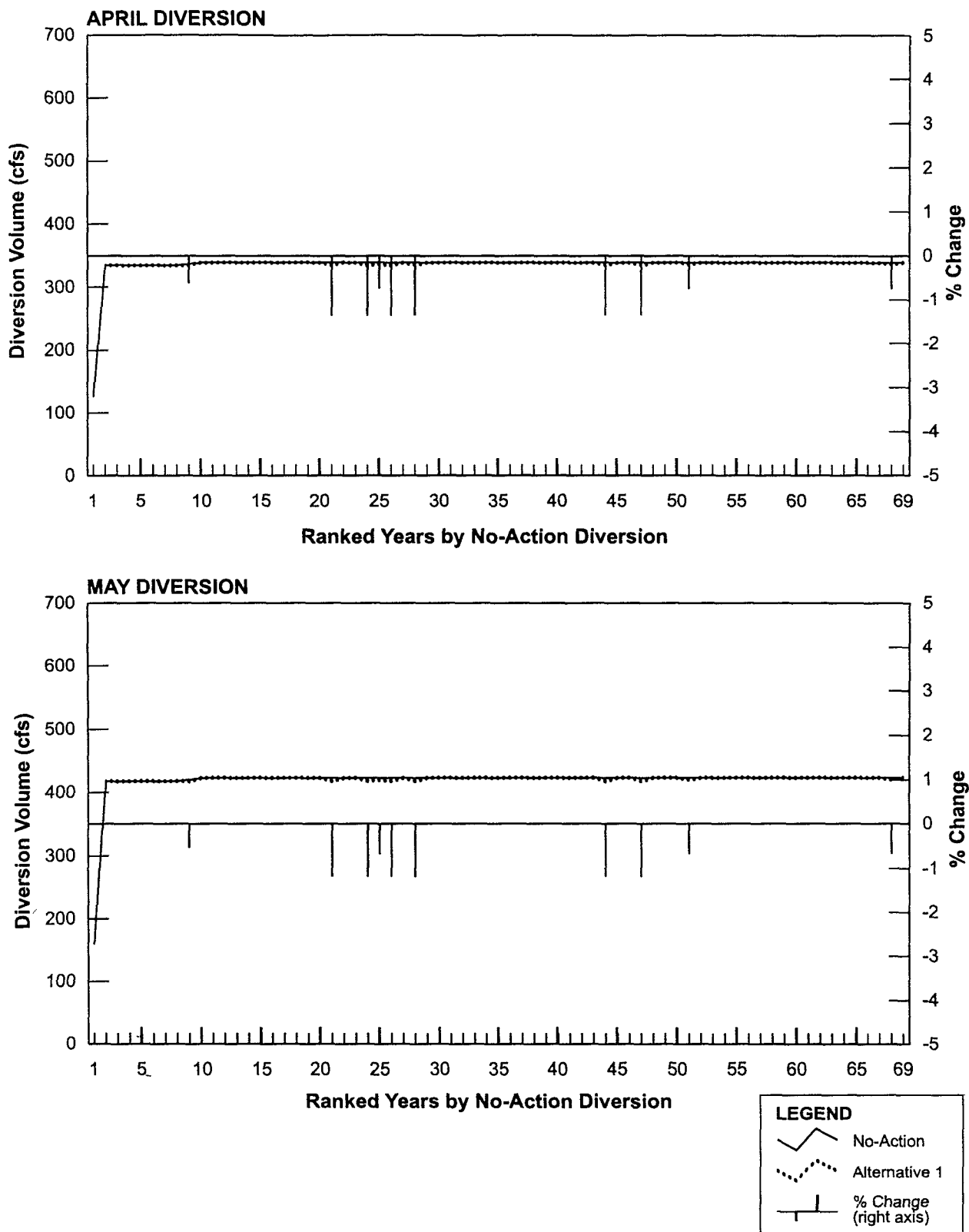


FIGURE III-9. CONTINUED

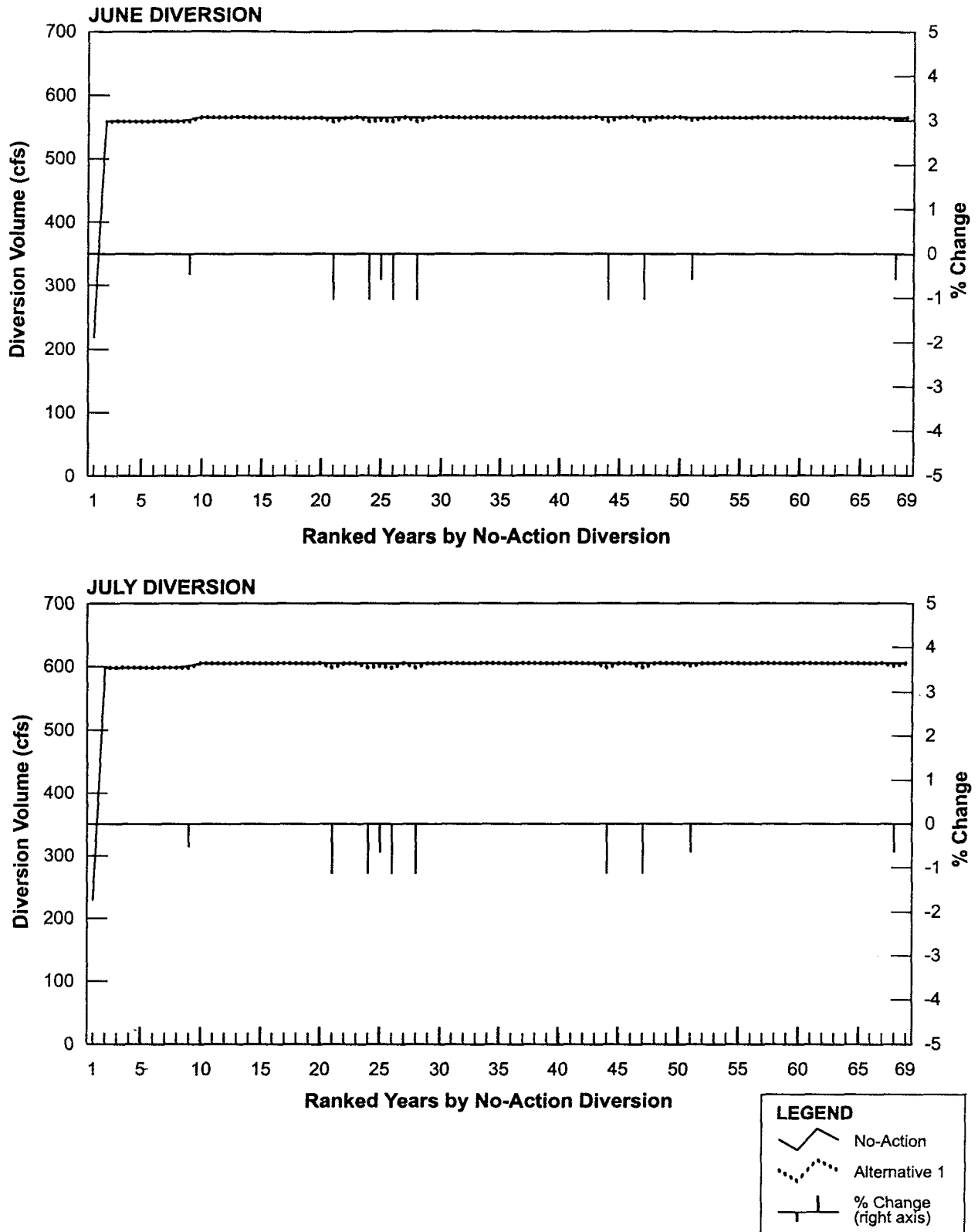


FIGURE III-9. CONTINUED

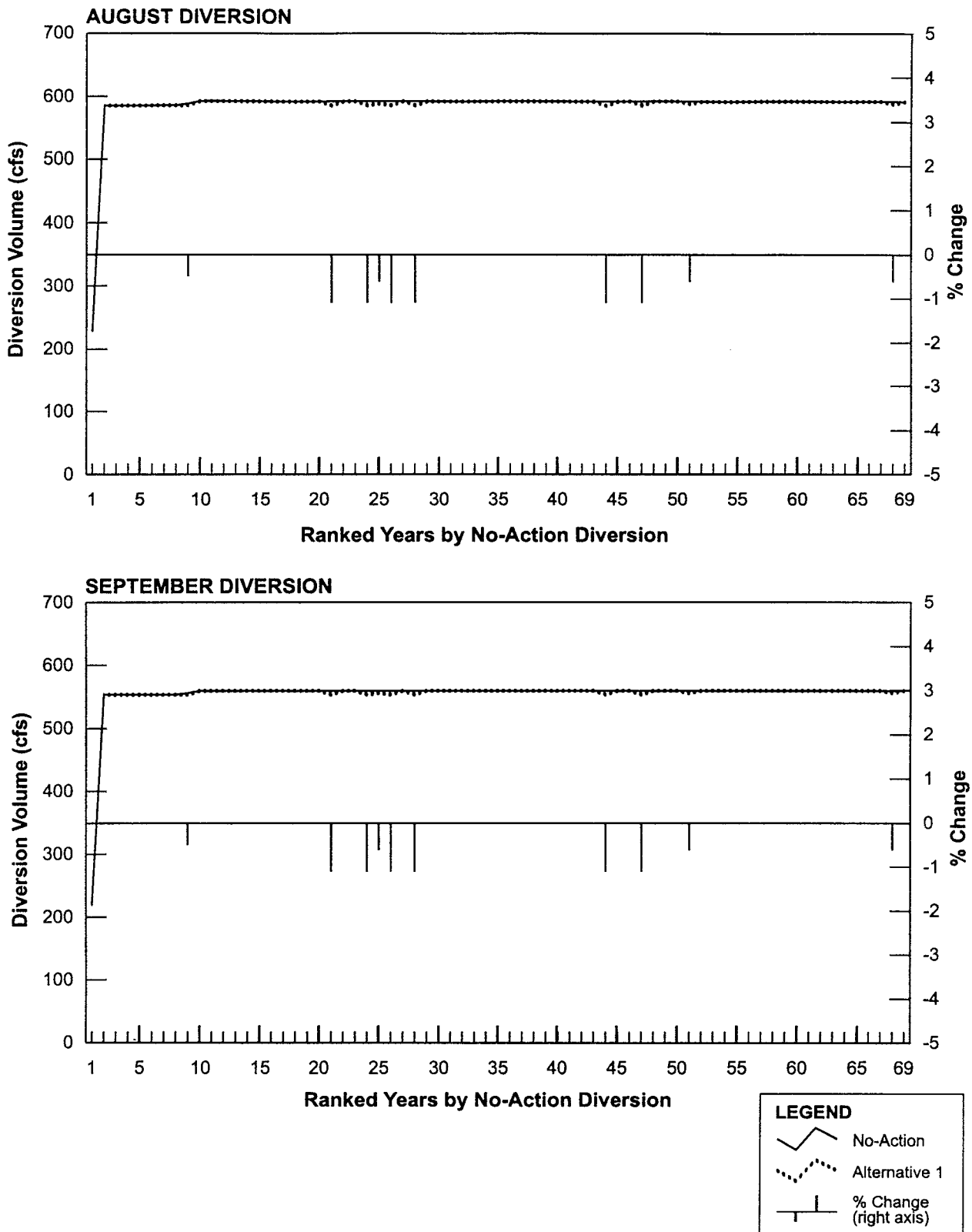


FIGURE III-9. CONTINUED

Step 3: Summary of Effects by Species and Overall Summary. In summary, improved diversion conditions would benefit fry and juvenile fall-run chinook salmon in the American River, which would contribute to the overall benefit for chinook salmon. Implementation of fish screen improvements is the primary method to achieve benefits for all representative species, because the percent reduction in diversion quantity is small. Eggs and larvae too small to be protected by fish screens would be lost to diversion under Alternative 1, as they would be under the No-Action Alternative.

Change in Water Surface Level

Changes in water surface levels may cause mortality by exposing redds, stranding individuals, reducing or eliminating cover, and other means. The effects of changes in water surface levels are assessed for rivers and reservoirs.

Streams and Rivers. Water surface-level conditions are assessed for chinook salmon and steelhead trout. Chinook salmon and steelhead trout lay eggs in redds. During periods when salmon and steelhead eggs and/or juveniles are present, decreases in water surface elevation would:

- dry out redds and desiccate eggs;
- reduce intragravel flow, causing adverse dissolved oxygen levels or providing conditions conducive to predation or disease;
- strand juvenile chinook salmon in habitat disconnected from the main river, where temperature, dissolved oxygen levels, and other factors cause mortality; and
- force juveniles into less optimal habitat, where food may be less available and vulnerability to predation may increase.

For the PEIS, average monthly water surface levels have been estimated based on average monthly river flows. Monthly average flows are inadequate for a detailed assessment of water surface-level conditions because impacts usually occur during short-term (e.g., hourly, daily) changes in water surface level. For this programmatic impact assessment, however, CVPIA actions that minimize flow reductions over short time intervals are assumed to improve water surface-level conditions for eggs and juveniles (Figure III-10).

Reservoirs. In reservoirs, water surface-level declines are referred to as drawdown. Spotted and largemouth bass lay eggs in redds constructed in shallow water. During periods when bass eggs and/or juveniles are present, reservoir drawdown would:

- dry out redds and desiccate eggs;
- provide conditions conducive to predation on eggs;
- strand juvenile bass in habitat disconnected from the reservoir where temperature, dissolved oxygen levels, and other factors cause mortality; and

SOURCE:
(1) Fisheries Technical Appendix Attachment B

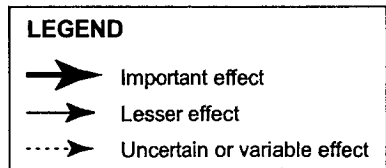
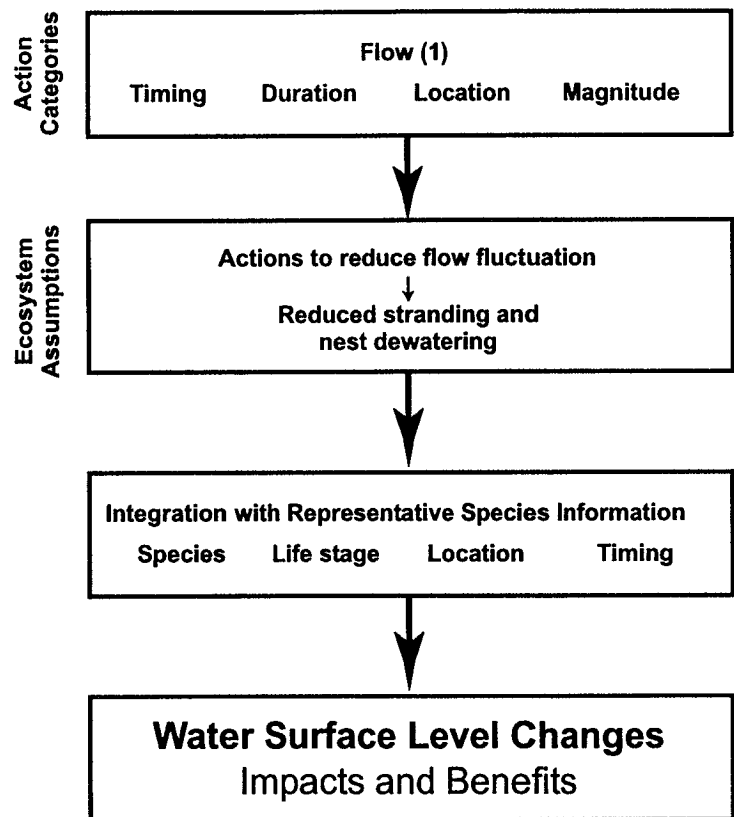


FIGURE III-10

PROPOSED ACTIONS AFFECTING WATER SURFACE LEVEL CHANGES

- force juveniles into less optimal habitat, where food may be less available and vulnerability to predation increases.

End-of-month reservoir surface elevations are simulated for the 69-year period of record for reservoirs in the study area, including Whiskeytown Lake, Shasta Lake, Lake Oroville, Folsom Lake, New Hogan Lake, New Melones Reservoir, New Don Pedro Reservoir, Lake McClure, Millerton Lake, and San Luis Reservoir. Monthly drawdown is calculated by comparing the end-of-month surface elevation for each month with the elevation in the preceding month. Increased rates of drawdown are assumed to increase drawdown-related losses during the months when spawning and rearing occur (Attachment A, Monthly Species Occurrence in Each Watershed Compartment by Life Stage). The effects of drawdown are not assessed for other reservoirs that may be affected by implementation of the CVPIA, including Camanche, Camp Far West, and New Bullards Bar reservoirs.

Example Change in Water Surface-Level Analysis: Alternative 1, American River, Fall-Run Chinook Salmon. For this example analysis, the effects of short-term water surface-level changes on fall-run chinook salmon in the American River under Alternative 1 are determined by comparing surface-level conditions under Alternative 1 with those under the No-Action Alternative.

Data Sources. Daily and hourly surface level data are not available for use in assessing the effects of changes in water surface level. However, CVPIA actions that specify minimizing flow reductions over short time intervals are addressed under Alternative 1. All actions that specify reduced flow fluctuations are identified in PEIS Attachment F.

Step 1: Assessment of Changes in Water Surface Level during Months when Species Are Present. Reduced flow fluctuations are identified for the American River under Alternative 1. Although timing is not identified, reduced fluctuation is assumed to occur when it would have the greatest ecological benefit. As indicated in Table A-1 of Attachment A, chinook salmon are present in the American River during the life stages and months described under Water Temperature.

The assessment of surface level change on juvenile migrations is included in the assessment for the rearing life stages (Table III-9). June, July, August, and September are not considered in the assessment of surface level change for fall-run chinook salmon rearing in the American River because relatively few individuals are present at that time relative to the other months.

Step 2: Assessment of Biological Effects of Water Surface Level Changes by Month. Reduced surface level fluctuations are assumed to reduce nest drying and egg desiccation; improve levels of intragravel dissolved oxygen; and reduce predation, disease, and juvenile stranding. Thus, egg, fry, and juvenile life stages would benefit.

Step 3: Summary of Effects by Species and Overall Summary. In summary, water surface-level fluctuations would be reduced for this example, resulting in improved survival of fall-run chinook salmon eggs, fry, and juveniles in the American River. The benefit contributes to the conclusion that chinook salmon in the American River would benefit under Alternative 1.

Pollutants

Pollutants are substances that cause mortality, reduce growth rates, or reduce reproductive success. The factors considered in the assessment of pollutants are flow and water quality. Increased flow dilutes pollutants and reduces concentration. Reducing the application of potential pollutants (e.g., by reducing agricultural acreage) and actions to clean up point and non-point pollution sources reduce inputs to rivers and the resulting concentration of pollutants that affect aquatic organisms (Figure III-11).

Many CVPIA actions related to pollutants have not yet been sufficiently defined to allow a quantitative assessment of changes in pollutant levels. The analysis for the PEIS assumes that CVPIA actions that would potentially reduce pollutant inputs to the system would benefit the aquatic ecosystem and would lead to reduced losses of most species and life stages of the representative species (Table III-9). Potential changes in the dilution of pollutants that may occur in response to flow changes are also evaluated (i.e., increased flow dilutes pollutants). The relationship between flow changes attributable to CVPIA actions and pollutant inputs, however, cannot be determined with available data.

Example Pollutant Analysis: Alternative 1, American River, Fall-Run Chinook Salmon. For this example analysis, the effects of pollutants on fall-run chinook salmon in the American River under Alternative 1 are determined by comparing water conditions under Alternative 1 with those under the No-Action Alternative.

Data Sources. Pollutant levels are affected by several factors: pollutant input, cleanup of polluted sites, and possibly flow conditions. However, many actions related to pollutants have not been defined in sufficient detail to allow a quantitative assessment of changes in pollutant levels, and the relationship between flow changes resulting from CVPIA actions and pollutant concentrations cannot be determined quantitatively based on available data.

For some watersheds, Alternative 1 directly addresses reducing pollutant input and cleaning up polluted sites, but this is not the case for the American River. However, Alternative 1 improves flow conditions, which could reduce pollutant levels through dilution. Actions that address water quality in other watersheds are identified in PEIS Attachment F.

Average monthly flow is simulated by Reclamation's operation models (as discussed in Attachment B). The 69-year simulation of monthly flow output from Reclamation's PROSIM and SANJASM models can be found in the PROSIM and SANJASM output and a sample, for this example, in Figure III-12.

Step 1: Assessment of Pollutants during Months when Species Are Present. Increased flow, but no water quality actions, are identified for the American River under Alternative 1. On the American River at Fair Oaks, flow increases relative to the No-Action Alternative from October through April (Figure III-12). Flow decreases relative to the No-Action Alternative during June through September.

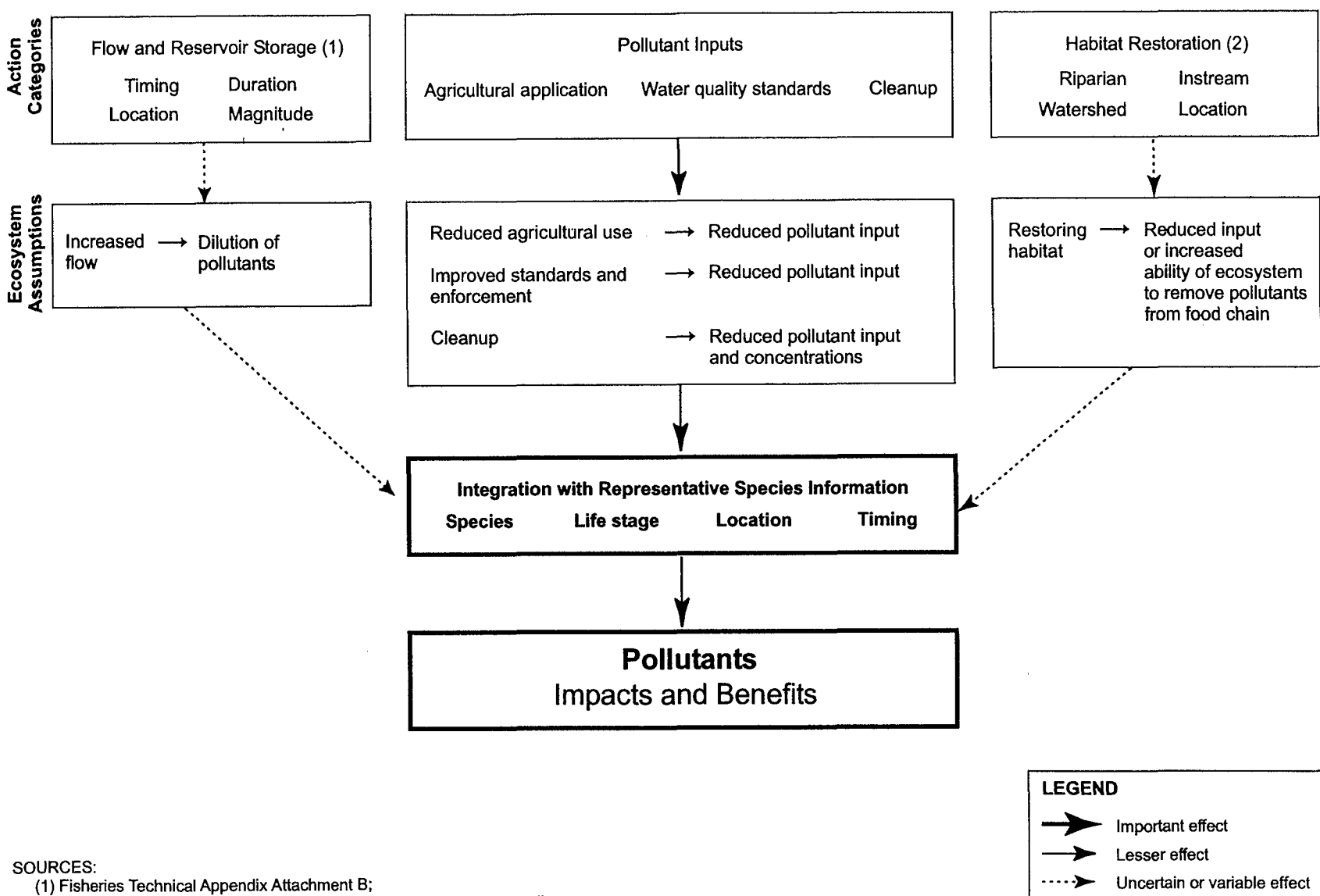


FIGURE III-11

PROPOSED ACTIONS AFFECTING POLLUTANTS

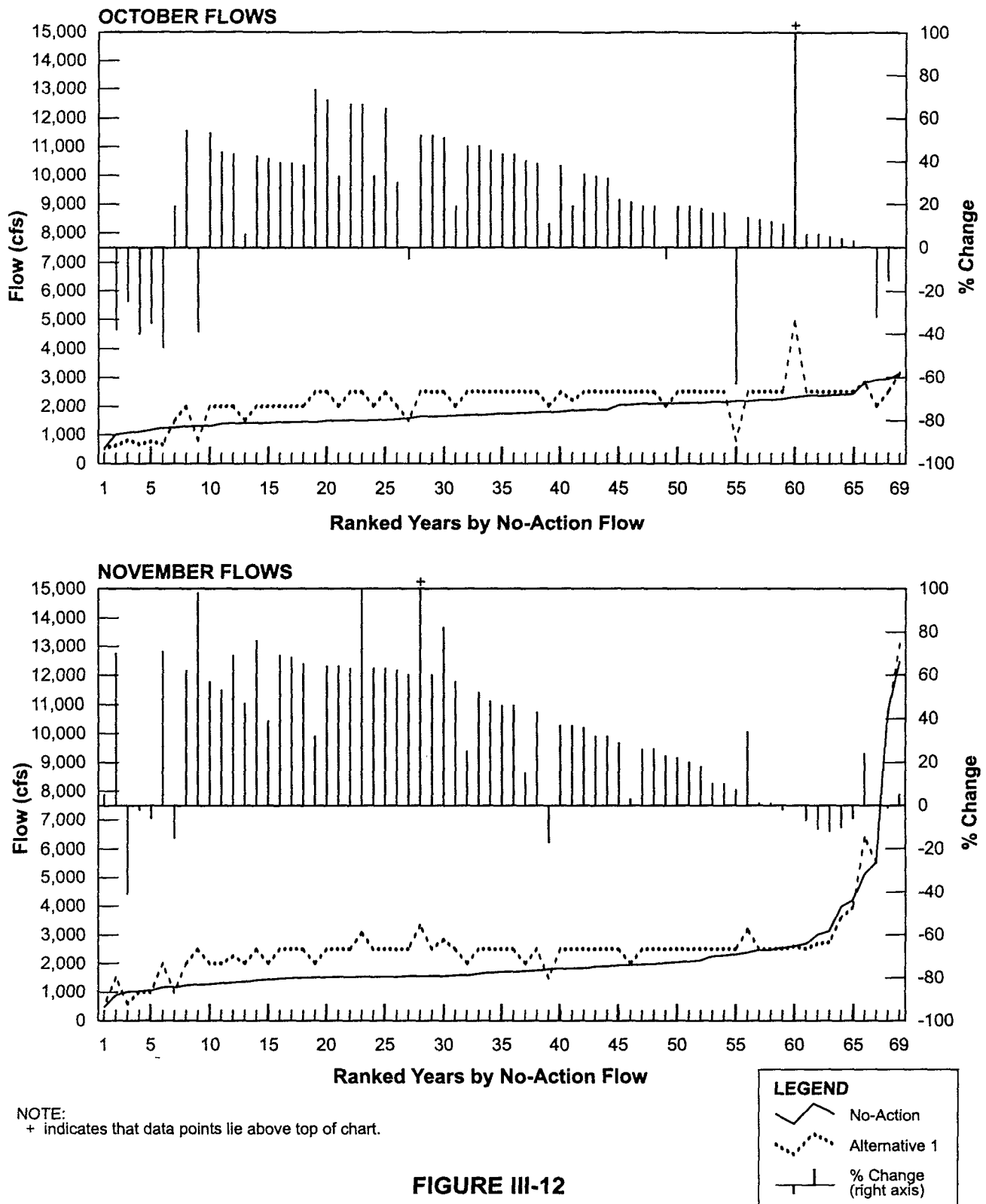
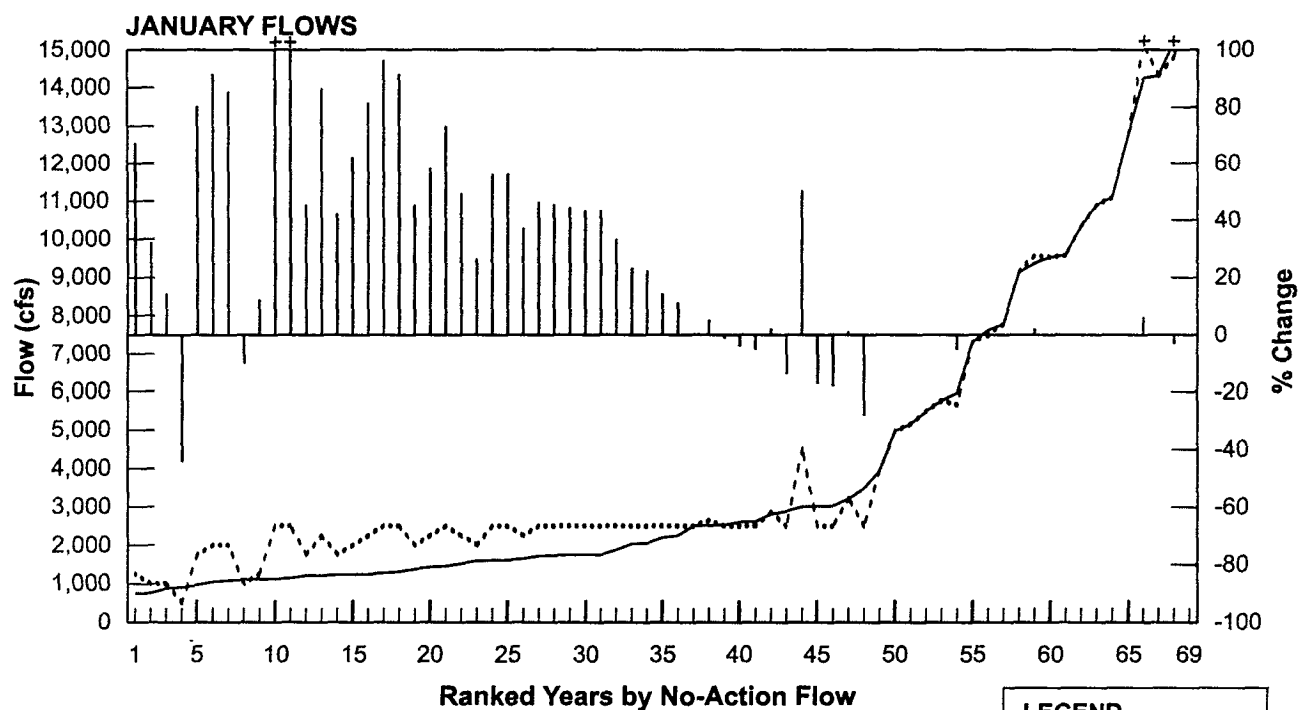
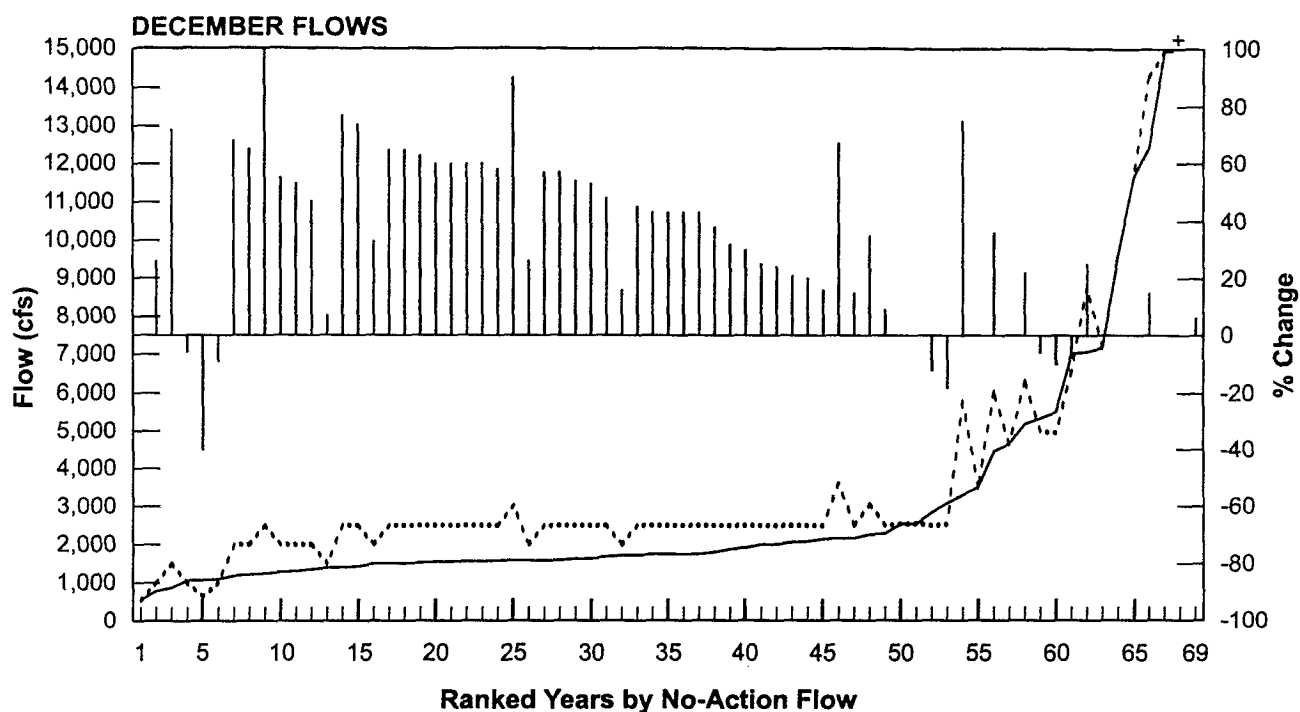


FIGURE III-12

**SIMULATED AMERICAN RIVER FLOW AT FAIR OAKS
FOR ALTERNATIVE 1 AND THE NO-ACTION ALTERNATIVE**



NOTE:
+ indicates that data points lie above top of chart.

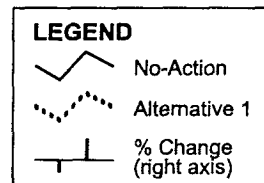
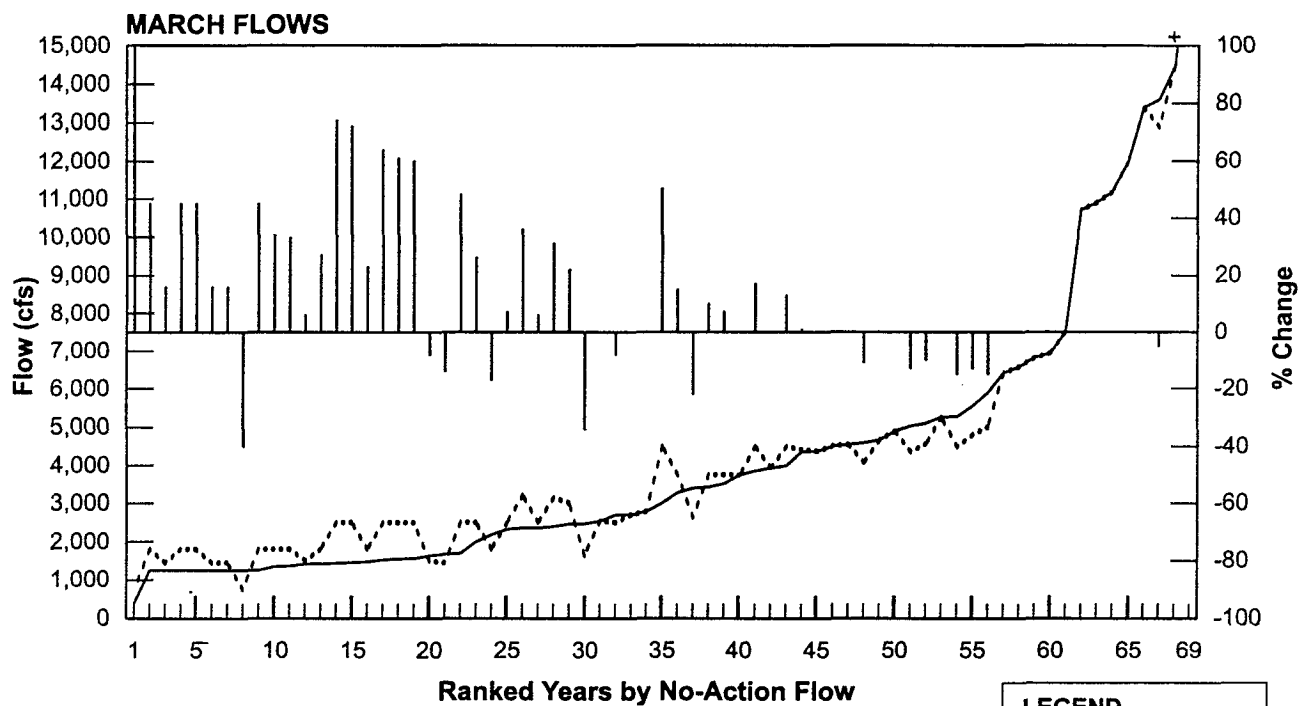
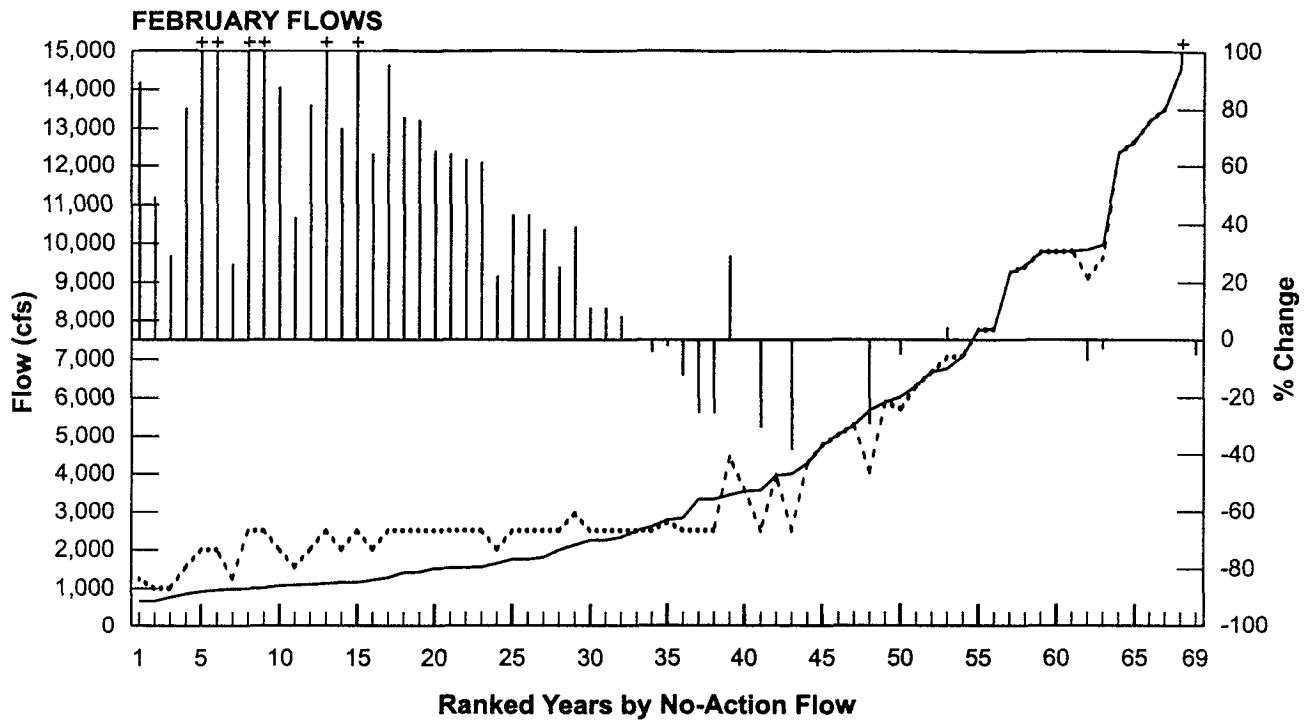


FIGURE III-12. CONTINUED



NOTE:
+ indicates that data points lie above top of chart.

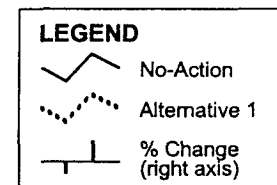
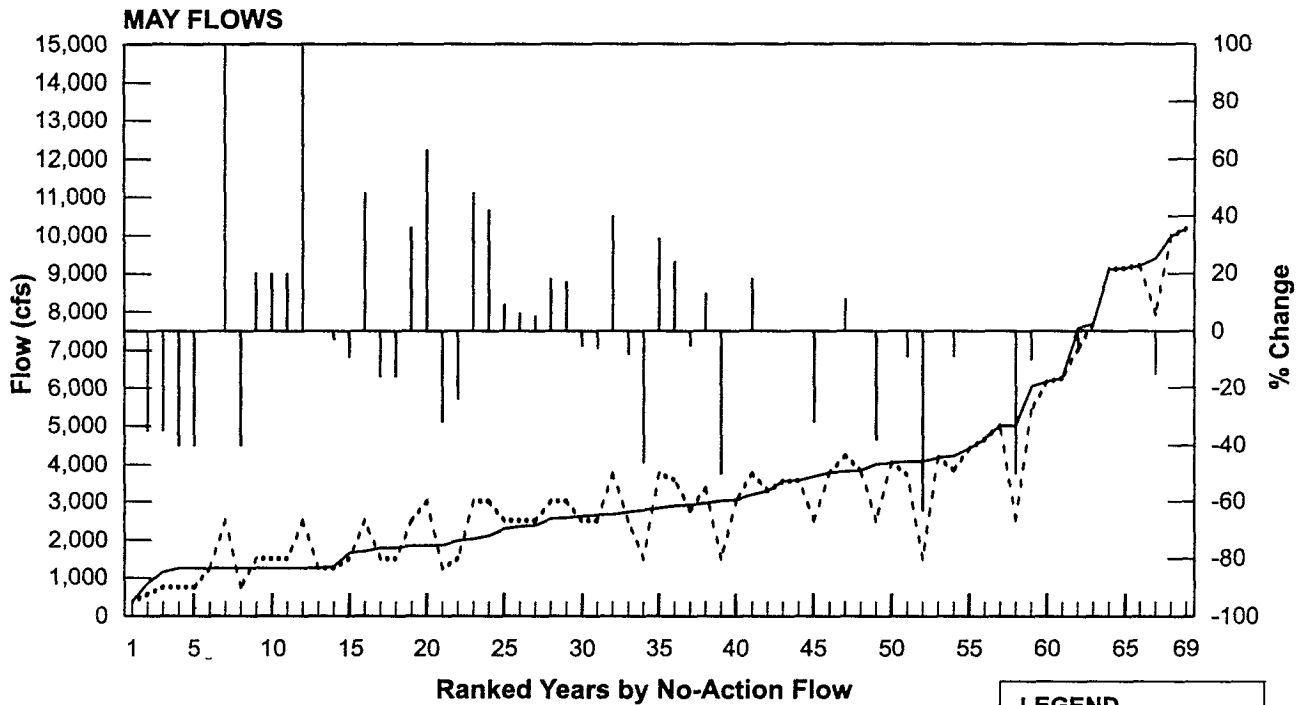
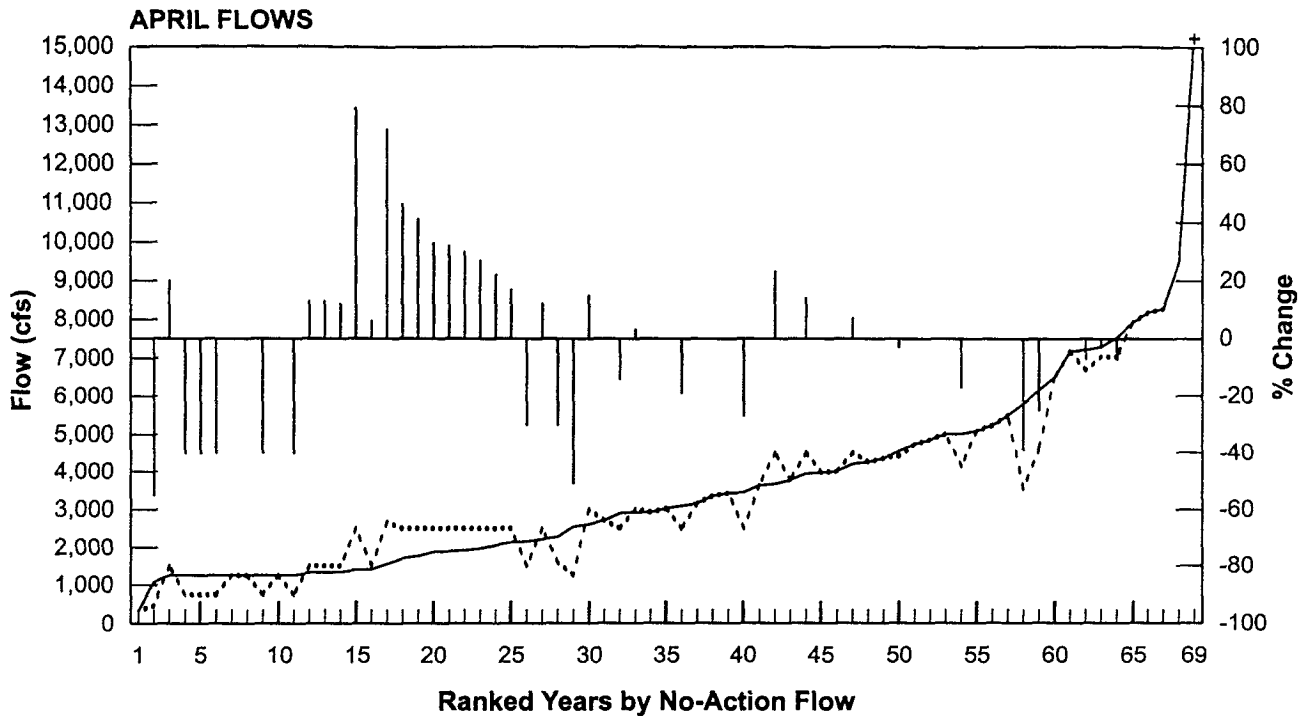


FIGURE III-12. CONTINUED



NOTE:

+ indicates that data points lie above top of chart.

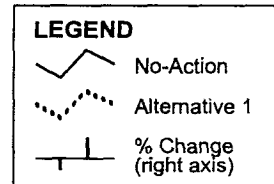


FIGURE III-12. CONTINUED

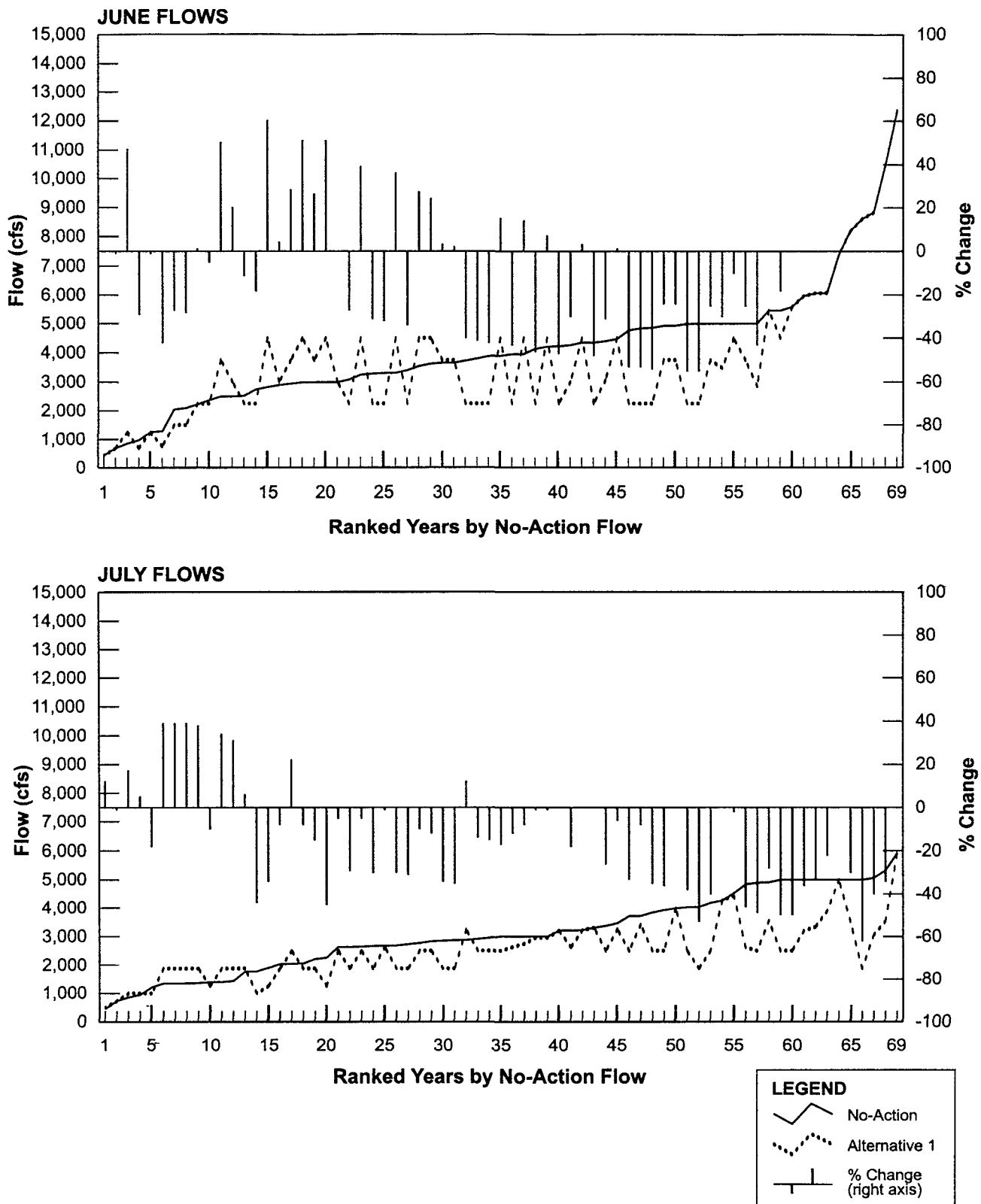


FIGURE III-12. CONTINUED

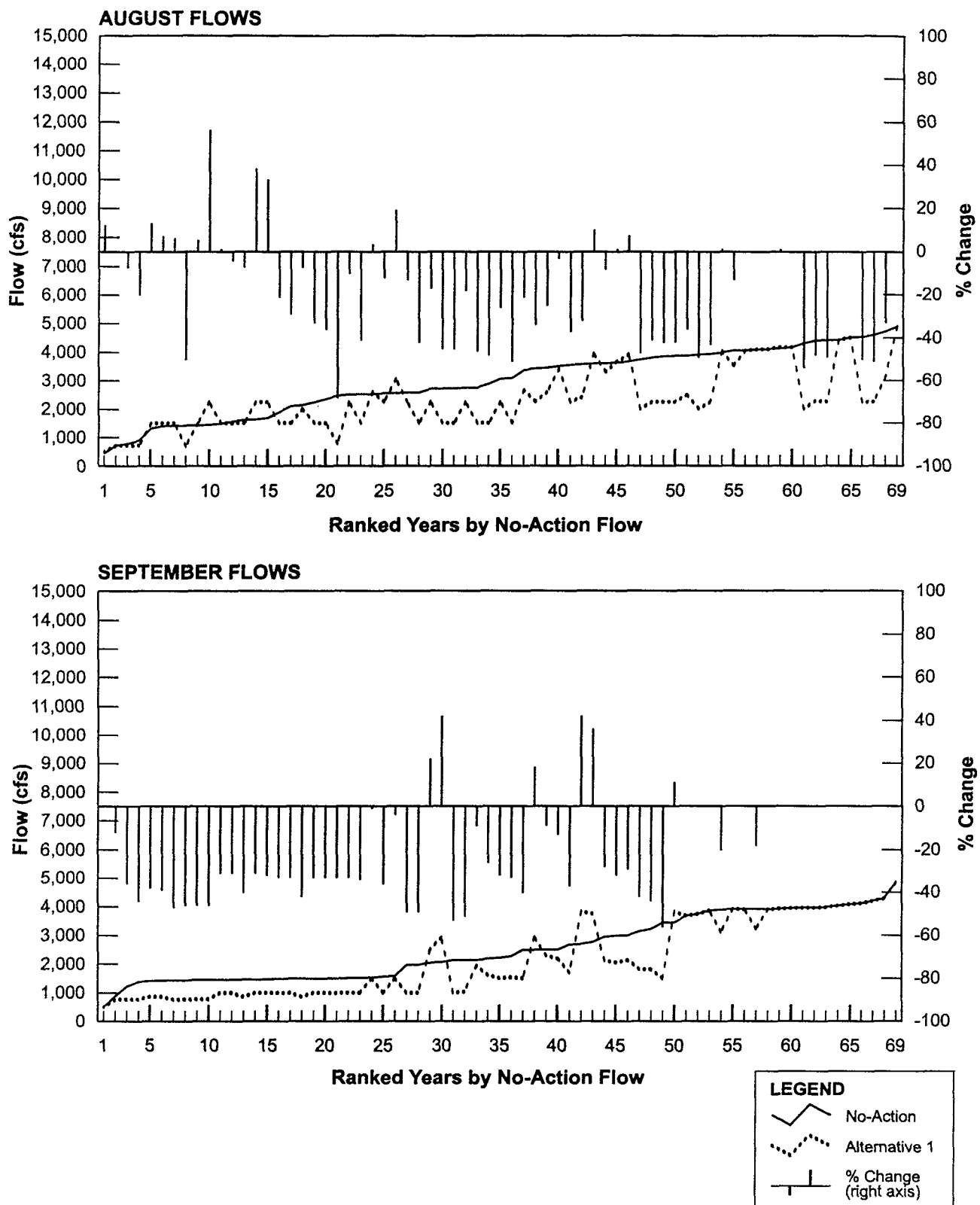


FIGURE III-12. CONTINUED

As indicated in Table A-1 of Attachment A, chinook salmon are present in the American River during the life stages and months described under Water Temperature.

Fall-run chinook salmon are susceptible to the effects of pollution during incubation and rearing, and to a lesser extent during juvenile migration. The assessment of pollutant effects on juvenile migration are included in the assessment for the rearing life stage (Table III-9). June, July, August, and September are not considered in the assessment of pollutants for fall-run chinook salmon in the American River because relatively few individuals are present at that time relative to other months.

Step 2: Assessment of Biological Effects of Pollutants by Month. As a result of increased flows, pollutant concentration may be reduced for those life stages present in the American River from October through April. Therefore, fall-run chinook salmon eggs, fry, and juveniles could benefit from potentially reduced pollutant concentrations. Because river flow in May under Alternative 1 does not clearly differ from that under the No-Action Alternative, pollutant levels may be similar to conditions under the No-Action Alternative. During the rest of the year, although concentrations may be increased because of reduced flows, life stages sensitive to pollutants are not present in the American River.

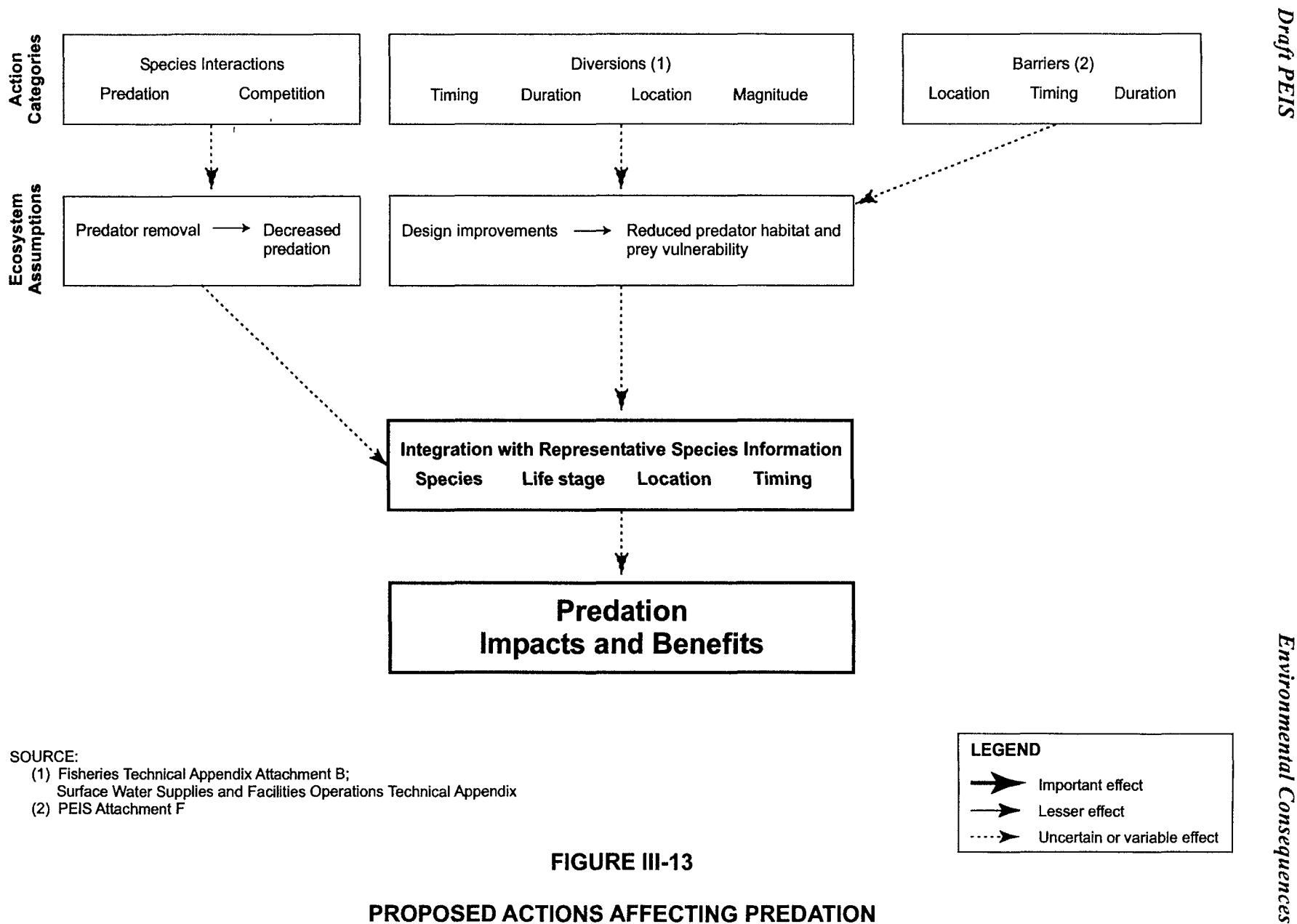
Step 3: Summary of Effects by Species and Overall Summary. In summary, the dilution of pollutants could benefit incubating and rearing life stages of fall-run chinook salmon in the American River. This assessment contributes to the conclusion that chinook salmon in the American River would benefit under Alternative 1. However, pollutants have not been identified as a concern for chinook salmon in the American River, and the precise effects of pollutant dilution are unknown. Impacts related to pollutants in the American River are not identified.

Predation

Predation is a natural environmental condition; however, predation may increase to adverse levels through changes in ecosystem structure that increase prey vulnerability or increase predator feeding efficiency. Increased prey vulnerability may also be associated with other environmental conditions, including water temperature conditions, diversion, change in water surface level, increased pollutant concentration, and fishing. Action categories used in the PEIS to evaluate predation include instream physical structures such as diversion facilities and barriers, and species interactions (Figure III-13) resulting from habitat created by these instream physical structures. Predation effects are assessed for juvenile chinook salmon. The analysis for the PEIS assumes that CVPIA actions that reduce predator habitat or the occurrence of juvenile chinook salmon in predator habitat would reduce predation on juvenile chinook salmon.

Example Predation Analysis: Alternative 1, American River, Fall-Run Chinook Salmon. For this example analysis, the effects of predation on fall-run chinook salmon in the American River under Alternative 1 are determined by comparing species interactions under Alternative 1 with those under the No-Action Alternative.

Data Sources. Predation is affected by the availability of predator habitat, such as that provided by human-made facilities (i.e., barriers and diversions), and by natural conditions (i.e.,



ponded sections of a river). For some watersheds, Alternative 1 includes actions that directly address predation by modifying facilities or altering stream conditions, but this is not the case for the American River. All qualitative actions that address reducing predation are identified in PEIS Attachment F.

Step 1: Assessment of Predation during Months when Species Are Present.

Alternative 1 does not address predation on the American River; therefore, conditions under Alternative 1 would be identical to those under the No-Action Alternative.

Step 2: Assessing Biological Effects of Predation by Month. Because predation would not change under Alternative 1, effects on fall-run chinook salmon would be exactly the same under Alternative 1 as under the No-Action Alternative.

Step 3: Summary of Effects by Species and Overall Summary. In summary, predation on fall-run chinook salmon in the American River would not differ from conditions under the No-Action Alternative.

Movement

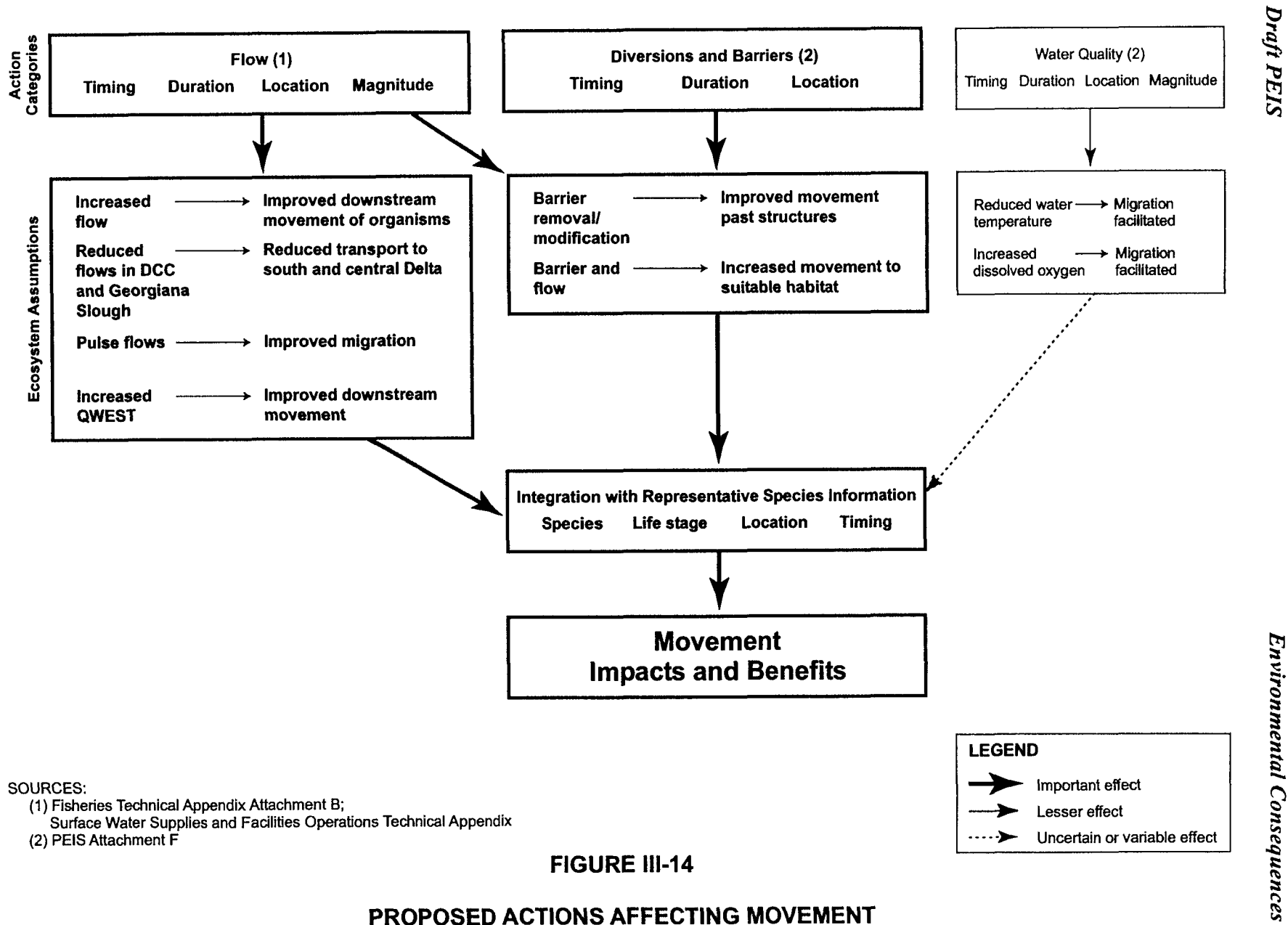
Movement of organisms can be passive, through transport flows, or active, by means of attraction flows. Factors important to movement include flow (i.e., velocity, turbulence, and direction), diversions, barriers, water quality, and physical habitat conditions. Conditions that support passive and active movement of eggs, larvae, juveniles, and adults to productive habitats (e.g., habitats that support essential organism activities) are assessed in this section. In the study area, movement is a concern for all representative species. The life stages affected by movement are species dependent (Table III-9).

American shad and striped bass are affected by conditions affecting movement during the planktonic egg and larval life stages. Chinook salmon, steelhead trout, American shad, striped bass, delta smelt, longfin smelt, and other species are affected during the downstream migration of juveniles. Chinook salmon, steelhead trout, white and green sturgeon, American shad, and other species are also affected during upstream migration of adults.

The action categories used to assess movement conditions include flow, diversion and barrier facilities which affect access to aquatic habitat, and water quality (Figure III-14).

The methods for assessing movement include the following assumptions:

- reduced river flow and passive movement during planktonic egg and larval transport increases mortality;
- passive movement using transport flow toward unproductive habitats during planktonic egg and larval transport and during downstream migration of juveniles increases mortality;
- passive movement using transport flows over or around barriers during the downstream migration of juveniles increases mortality;



- presence of inappropriate flow-related cues (e.g., agricultural return flow, river flow, water temperature) during migration increases mortality; and
- absence of appropriate flow-related cues (e.g., pulse flows, turbidity, water temperature) during migration increases mortality.

Reduced river flows may increase mortality during the downstream transport of striped bass and American shad planktonic eggs and larvae. Although the mechanism causing increased mortality of eggs and larvae is unclear, low river flow is associated with low survival of striped bass eggs and low fall abundance of young-of-year American shad (DFG, 1987; Stevens and Miller, 1983). Average monthly river flows are simulated for the 69-year period of record for rivers in the study area, including the Sacramento, Feather, Yuba, American, Mokelumne, Stanislaus, and the San Joaquin rivers (Surface Water Supplies and Facilities Operations Technical Appendix). Reduced flows (compared to the No-Action Alternative) during the primary occurrence of eggs and larvae are assumed to degrade transport conditions.

In the Delta, a portion of the flow from the Sacramento River enters the Delta Cross Channel (DCC) and Georgiana Slough. Egg and larval striped bass transported down the Sacramento River are assumed to enter the DCC and Georgiana Slough in proportion to the amount of Sacramento River flow entering these channels. Eggs and larvae carried into the central Delta through the DCC and Georgiana Slough are exposed to a higher probability of entrainment in diversions compared to eggs and larvae that continue down the Sacramento River.

The division of flow from the Sacramento River into the DCC and Georgiana Slough and the division of flow from the San Joaquin River into Old River at Mossdale also affect juvenile chinook salmon and steelhead trout survival. Outmigrating juvenile chinook salmon are assumed to enter the DCC, Georgiana Slough, and Old River at Mossdale in proportion to the net flow division from the Sacramento and San Joaquin rivers (Service, 1987). The mortality of juvenile chinook salmon that move into the DCC and Georgiana Slough from the Sacramento River is greater than the mortality of juvenile chinook salmon that continue down the Sacramento River toward Rio Vista. The mortality of juvenile chinook salmon that move into Old River is greater than the mortality of juvenile chinook salmon that continue down the San Joaquin River toward Stockton (Service, 1987 and 1990). Increased mortality may be attributable to predation, adverse water temperature, pollutants, and diversion. Information for chinook salmon is assumed applicable to steelhead trout. American shad and other species could also be affected by the DCC and Georgiana Slough flow division, but information on passive transport effects on these species in the Delta is not currently available.

Monthly average channel flows are simulated for the Sacramento-San Joaquin Delta (Attachment B and Surface Water Supplies and Facilities Operations Technical Appendix). Increases in the proportion of Sacramento River flow entering the DCC and Georgiana Slough and increases in the proportion of San Joaquin River flow entering Old River at Mossdale are assumed to increase the mortality of juvenile chinook salmon and steelhead trout and eggs and larvae of striped bass. The effects of barrier operation (e.g., DCC gates, Old River barrier) on net channel flow are reflected in the simulation.

Juvenile chinook salmon and steelhead trout move with flow through, over, or around barriers during downstream migration. Mortality may result from abrasion and predation associated with the barrier or flow patterns created by the barrier (e.g., mortality of juvenile chinook salmon at RBDD [Vogel, 1995]). Barriers may provide habitat and increased feeding opportunity for predatory fish (e.g., disorientation and delayed migration of juvenile fish). For the impact assessment, CVPIA actions that address effects of barriers, including predation associated with barriers, are assumed to improve transport conditions for juvenile chinook salmon and steelhead trout.

Flow-related cues attract adult salmon into unproductive habitat where reproduction is unsuccessful (e.g., migration up the San Joaquin River past the mouth of the Merced River, migration into the Colusa Basin drain). The environmental conditions that affect attraction during migration are flow and water quality. Adult chinook salmon and steelhead trout benefit from barriers that block movement into unproductive habitat and force the fish to continue migration to productive habitat. Potential changes in flow-related attraction to non-salmonid habitat in agricultural return flow are not evaluated because information on the relationship between flow and adult salmon behavior cannot be determined with available data.

Flow-related cues may delay the movement of organisms out of unproductive habitat or into habitat essential for completing their life cycle. In rivers, migration cues for juvenile chinook salmon and steelhead trout are poorly understood and flow-migration relationships are not developed. CVPIA actions include identification of pulse flows to facilitate successful juvenile salmonid outmigration; however, information on the need and timing for pulse flows is currently unavailable. For the impact assessment, CVPIA actions that address pulse flows are assumed to provide cues that prevent outmigration delay and support migration of juveniles toward marine habitat, essential for completing chinook salmon and steelhead life cycles.

In the Delta, the movement of river flow toward the SWP and CVP diversions in the south Delta may create conditions that delay the movement of organisms from unproductive habitat into habitat essential for completing their life cycles. Changes in the net Delta channel flow toward Suisun Bay are assessed for chinook salmon, steelhead trout, striped bass, delta smelt, and longfin smelt. This analysis is based on the assumption that reduced net Delta channel flow toward Suisun Bay degrades attraction conditions. This assumption is not strongly supported by research; however, some data indicate that increases in the net flow of water from the central Delta toward the lower San Joaquin River (i.e., QWEST) may increase survival of juvenile chinook salmon (Service, 1993). In addition, increased net Delta outflow increases the proportion of young-of-year striped bass and delta smelt in Suisun Bay (DFG, 1992; DWR and Reclamation, 1993). Increased net Delta outflow has also been associated with increased young-of-year abundance for striped bass and longfin smelt (DFG, 1992; Jassby, 1993). The assumption that reduced net Delta channel flow toward Suisun Bay degrades attraction conditions is conservative and ensures that potential adverse effects and benefits are identified.

Average monthly channel flows are simulated for the Sacramento-San Joaquin Delta (see Attachment B and Surface Water Supplies and Facilities Operations Technical Appendix). Reduced QWEST and net Delta outflow are assumed to degrade attraction conditions.

Example Movement Analysis: Alternative 1, American River, Fall-Run Chinook Salmon. For this example analysis, changes in the conditions affecting the movement of fall-run chinook salmon in the American River under Alternative 1 are determined by comparing flow conditions (in particular, provision of pulse flows) under Alternative 1 with those under the No-Action Alternative. Migrating juvenile fall-run chinook salmon are affected by those river conditions that affect movement.

Data Sources. Movement of fall-run chinook salmon on the American River would be affected by flow. Pulse flows are assumed to improve downstream juvenile migration. Pulse flows on the American River are specified actions under Alternative 1. Movement is assessed qualitatively for fall-run chinook salmon on the American River. However, for other species and life stages, simulated flow conditions would also be considered (see simulated operations data on CD-ROM). Actions that address pulse flows are identified in PEIS Attachment F.

Step 1: Assessment of Movement during Months when Species Are Present. Although the timing of pulse flows is not identified in Alternative 1, flows are assumed to occur when they would have the greatest benefit

As indicated in Table A-1 of Attachment A, chinook salmon are present in the American River during the life stages and months described under Water Temperature.

Movement is assessed for migrating juveniles. Because pulse flows benefit juvenile chinook salmon migration, only migrating juveniles are considered in this example analysis. Hence, only February, March, April, and May are assessed for conditions affecting movement (Table III-9).

Step 2: Assessment of Biological Effects of Movement by Month. Providing pulse flows is assumed to provide cues that support or encourage downstream migration of juvenile fall-run chinook salmon. Also, for the purpose of this PEIS and because timing of pulse flows is not specified, pulse flows are assumed to occur during the primary migration period (February, March, April, and May). Thus, movement effects relating to pulse flows are beneficial for migrating juvenile fall-run chinook salmon during February through May.

Step 3: Summary of Effects by Species and Overall Summary. In summary, pulse flows improve conditions affecting movement and would benefit fall-run chinook salmon in the American River.

Quantity and Quality of Habitat

Assessing changes in the quantity and quality of habitat involves evaluating physical, chemical, and biological conditions that support essential organism activities, including spawning, feeding, respiration, assimilation, predator avoidance, and resting. In the study area, loss of habitat has been a factor in the decline of many species, and providing habitat is critical to maintaining and increasing current fish populations. Habitat is an important requirement for all life stages of all species (Table III-9). Three types of aquatic habitat, riverine, estuarine, and reservoir, are discussed.

Action categories affecting the quantity and quality of habitat include flow and reservoir water surface elevation; temperature; habitat restoration actions (such as substrate, physical habitat, and water quality); and physical barriers that limit habitat use (Figure III-15).

Riverine Habitat. Riverine habitat is critical to chinook salmon, steelhead trout, striped bass, American shad, green sturgeon and white sturgeon, and Sacramento splittail. Habitat needs are life stage dependent. The following assumptions were used to assess the change in habitat quantity and quality:

- Restoring riparian, channel, and floodplain habitat increases spawning and rearing habitat availability.
- Extending cool-water zones downstream during spawning and rearing periods increases spawning and rearing habitat availability.
- Increasing flow during spawning and rearing periods generally increases spawning and rearing habitat availability.
- Removing or modifying physical barriers provides access to additional habitat.

CVPIA actions to restore habitat include actions to stop degradation of existing habitats, restore meander belts, restore riparian vegetation, restore spawning gravel, create side channels, limit bank protection, and prevent illegal stream alterations. Descriptions of these CVPIA habitat restoration actions are as yet insufficiently detailed to allow a quantitative assessment of the benefits of each action. This analysis assumes that CVPIA actions to restore habitat would benefit the aquatic ecosystem. Restoration of spawning gravel would benefit primarily chinook salmon and steelhead trout. Restoration of meander belts would increase rearing habitat for all species, increase spawning habitat for Sacramento splittail, and restore natural processes that maintain channel and riparian conditions. Depending on location, other restoration actions could potentially improve habitat conditions for chinook salmon, steelhead trout, striped bass, American shad, green sturgeon and white sturgeon, and Sacramento splittail.

In addition to improving water temperature conditions, as discussed previously, extending cool-water zones farther downstream increases spawning and rearing habitat availability for chinook salmon and steelhead trout. The life stages that benefit most from the additional cool-water habitat are spawning-incubation and rearing. Water temperature is the primary factor used in this analysis. Habitat restoration actions, change in reservoir operations (including operation of multilevel release structures), and change in river flow can affect water temperature in study area rivers.

The assessment of cool-water habitat availability was conducted for rivers where information was available. Average monthly water temperature is simulated for 69 years (water years 1922-1990) for Clear Creek and the Sacramento, Feather, American, and Stanislaus rivers. As discussed under Water Temperature, the water temperature models compute river water temperature at various locations (i.e., nodes) downstream from a major reservoir for each river mentioned above. Change in water temperature outside of the optimal range for chinook salmon and steelhead trout is assumed to change habitat availability (e.g., increased water temperature

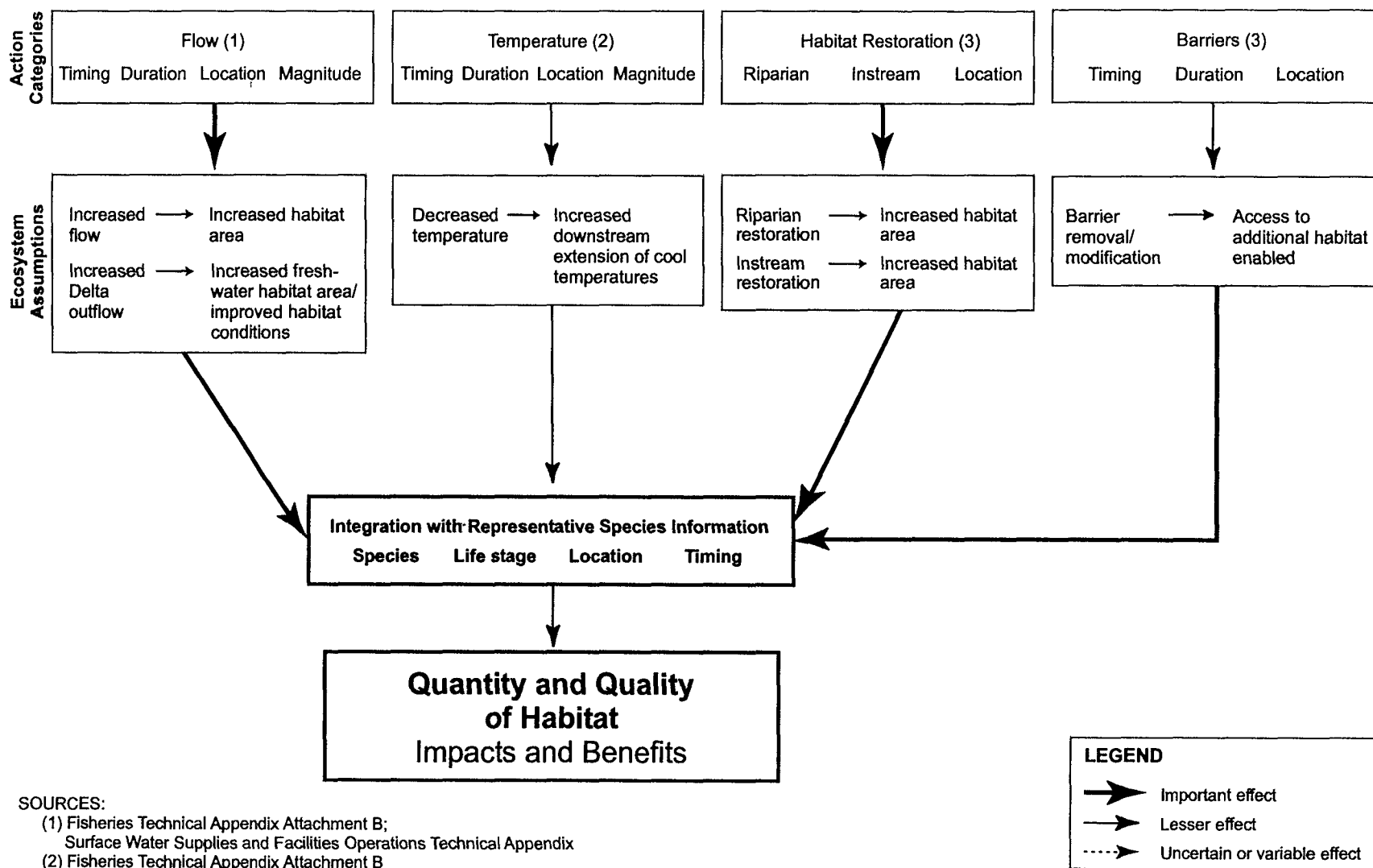


FIGURE III-15

PROPOSED ACTIONS AFFECTING QUANTITY AND QUALITY OF HABITAT

would reduce habitat availability) (Figures III-4 and III-5). The assessment methods identified under Water Temperature that were applied to rivers where simulated water temperatures are not available and that were used to evaluate the factors not accounted for in the simulated water temperature were also used in this analysis.

CVPIA actions to restore habitat also relate to change in flow below major reservoirs, including flushing flow to remove fine sediment and maintain channel structure and riparian growth. Most biologists agree that flow is a necessary component of fish habitat and that habitat availability is a useful index in identifying flow-habitat relationships (Bourgeois et al., 1996). The Service and DFG maintain that available instream flow studies for Central Valley rivers inadequately quantify available habitat for chinook salmon and steelhead trout (Snider, pers. comm.). Instream studies tend to bias habitat preference and use to shallower habitats that are readily surveyed. At higher water velocities and in deeper water, habitat may be underestimated, especially in larger rivers (Snider, pers. comm.).

For the PEIS, increases in flow are assumed to increase habitat availability for chinook salmon, steelhead trout, striped bass, American shad, green sturgeon and white sturgeon, and Sacramento splittail. Increased flow during the migration of adult American shad, green sturgeon and white sturgeon, and Sacramento splittail is assumed to improve access to habitat. Flow also affects water quality in the San Joaquin River near Stockton, which affects the upstream passage of chinook salmon. CVPIA actions that increase flow in the San Joaquin River past Stockton during migration of adult fall-run chinook salmon are assumed to increase access to upstream habitat. For example, a barrier on Old River near Mossdale increases flow down the San Joaquin River, increases dissolved oxygen levels, reduces water temperature, and increases access to upstream habitat for fall-run chinook salmon. Average monthly river flows are simulated for the 69-year period of record for rivers in the study area, including the Sacramento, Feather, Yuba, American, Mokelumne, Stanislaus, Tuolumne, Merced, and San Joaquin rivers (Surface Water Supplies and Facilities Operations Technical Appendix). Flow needs, usually associated with water-year types, were identified by the Service (1995a, 1995b) and are based on a reasonable balance of biological needs and water availability. For the simulated rivers, reservoir releases of allocated water were simulated to meet the flow needs identified by the Service.

CVPIA actions that remove physical barriers or improve movement over barriers (i.e., fish ladders) improve access to upstream habitat. Access to habitat in small tributary streams to the Sacramento River, critical to chinook salmon and steelhead trout, is most affected. Meander belt restoration, which may include levee removal or setback, may affect physical access to potential spawning habitat for Sacramento splittail.

Sacramento-San Joaquin Delta Estuary Habitat. Delta and estuarine habitat is critical to all of the representative species (except reservoir species) (Table III-9). Habitat needs are life stage dependent. The following relationships were used in assessing the provision of estuarine habitat:

- Adding new and improving existing riparian, channel, and shallow water habitat increases spawning and rearing habitat availability.
- Increasing flow increases spawning and rearing habitat availability.

CVPIA actions to restore habitat include actions that may stop degradation of existing habitats, restore riparian vegetation, limit bank protection, and restore shallow-water habitat. Habitat restoration actions have not yet been sufficiently defined to specifically describe their expected benefits for existing habitats and species. The analysis for the PEIS assumes that CVPIA actions to restore habitat in the Delta would benefit the aquatic ecosystem. Restoration of shallow water habitat would increase rearing habitat availability for all species and spawning habitat availability for delta smelt, longfin smelt, and Sacramento splittail. Other restoration actions are assumed to potentially improve habitat conditions for most life stages of all species using the Delta.

The abundance of numerous fish and invertebrate species in the Sacramento-San Joaquin Delta estuary is correlated with Delta outflow. Investigators have suggested that outflow affects species abundance through its effects on estuarine habitat (Moyle et al., 1992). However, attempts to quantify the effects of outflow on estuarine habitat have been limited. Statistically significant relationships have been demonstrated between abundance indices of the species evaluated and Delta outflow or X2 (Jassby, 1992), where X2 is the in-channel distance upstream of the Golden Gate Bridge in kilometers where the near-bottom salinity is 2 ppt. The effect of habitat area on species abundance is difficult to separate from effects of other factors related to outflow, such as residence time, nutrient inputs, sediment transport, transport of eggs and larvae, entrainment in diversions, and dilution of pollutants. Nevertheless, estimated habitat area is correlated with species abundance (Table III-10) and is assumed to be a reasonable tool for assessing impacts in the PEIS.

TABLE III-10
RELATIONSHIP BETWEEN ABUNDANCE AND HABITAT
AREA FOR SELECTED SPECIES

Species	Years	Regression Equation (1)	R ²
Delta smelt	1967-1993	$Y = 1.713 + 0.019 (\text{OSHA})$	0.19
Longfin smelt	1967-1993	$Y = 0.156 + 0.018 (\text{OSHA})$	0.70
Striped bass	1959-1993	$Y = -36.705 + 1.069 (\text{OSHA})$	0.40
Bay shrimp	1980-1993	$Y = -322.357 + 2.532 (\text{OSHA})$	0.75
NOTE:			
(1) Delta and longfin smelt: $Y = \log_{10} (\text{MWT Index} + 1)$.			
Striped bass: $Y = 30\text{-millimeter index}$.			
Bay-shrimp: $Y = \text{Bay Survey Juvenile Index}$.			
OSHA = optimal salinity habitat area.			

Estuarine salinity is an important habitat factor for striped bass, delta smelt, and longfin smelt. Salinity is strongly affected by outflow; therefore, estuarine habitat often is defined in terms of a salinity range (Hieb and Baxter, 1993). Striped bass, delta smelt, and longfin smelt are assumed to have optimal salinity ranges, although salinity preferences are often specific to life stage. Species survival may be determined partly by the amount of habitat available within the optimal salinity range. Because the survival rates of early life stages often determine the size of year

classes, which in turn affect the size of the adult populations, the optimal salinity habitat of the limiting life stage may be particularly important.

Spawning habitat availability for longfin and delta smelt are assumed to increase with increased Delta outflow and with increased downstream extent of freshwater habitat. For rearing, optimal salinity needs are identified for each species. The lower salinity limit for young-of-year striped bass is 0.1 ppt and the upper salinity limit is 2.5 ppt. For juvenile delta smelt, the lower limit is 0.3 ppt and the upper limit is 1.8 ppt. Juvenile longfin smelt have a lower salinity limit of 1.1 ppt and an upper salinity limit of 21.6 ppt. (DFG summer tow net data.)

Simulated monthly Delta outflow was used to estimate X2. The distance upstream from the Golden Gate Bridge of the salinity lines representing the upper and lower limits of the optimal salinity range was computed from X2 using a logistic equation derived from longitudinal salinity profiles (Monismith, 1993) (Figure III-16).

Because the Sacramento-San Joaquin Delta Estuary has a complex shape, the area of optimal salinity habitat varies greatly with its location. Surface area, rather than volume, was used to quantify optimal salinity habitat because habitat surface area is believed to affect most of the selected species more directly than habitat volume and surface area is calculated more easily with available information. Tracings of nautical charts (prepared by Reclamation) were used to measure shore-to-shore width perpendicular to the main shipping channel at each kilometer of distance along the channel upstream from the Golden Gate Bridge. These widths were then used to estimate Estuary surface area (Figure III-17). The shorelines on the nautical charts represent mean lower low tide position. Total surface area of optimal salinity habitat was computed by summing all the widths (measured in kilometers) contained within the upstream and downstream limits of the habitat. The South Bay was not included in the analyses. The habitat area within the optimal salinity range for these species decreases with increased outflow from approximately a river distance of 40 to 60 kilometers upstream of the Golden Gate Bridge (i.e., reduced X2) (Figure III-18). The exception is the amount of habitat area for striped bass and delta smelt increases with increased outflow within the same area upstream of the Golden Gate Bridge.

Average monthly X2 is simulated for the Sacramento-San Joaquin Delta (Attachment B and Surface Water Supplies and Facilities Operations Technical Appendix). The relationships previously described (Figure III-18) are used to assess changes in habitat in response to changes in Delta outflow.

Reservoir Habitat. Reservoir water surface area plays an important role in defining reservoir fish productivity (Jones & Stokes Associates, 1990; Leidy and Myers, 1984; Lee, pers. comm.). Higher reservoir surface elevations (representing greater surface area) typically provide greater spawning opportunities, cover, and habitat diversity and result in more diverse and larger fish populations. At high reservoir surface elevations, the physical living space available for fish increases and the diversity and quality of the habitat are generally improved.

For the PEIS, higher reservoir surface elevations are assumed to increase spawning and rearing habitat availability. End-of-month reservoir surface elevations are simulated for the 69-year period of record for reservoirs in the study area, including Whiskeytown Lake, Shasta Lake, Lake Oroville, Folsom Lake, New Hogan Lake, New Melones Reservoir, New Don Pedro Reservoir,

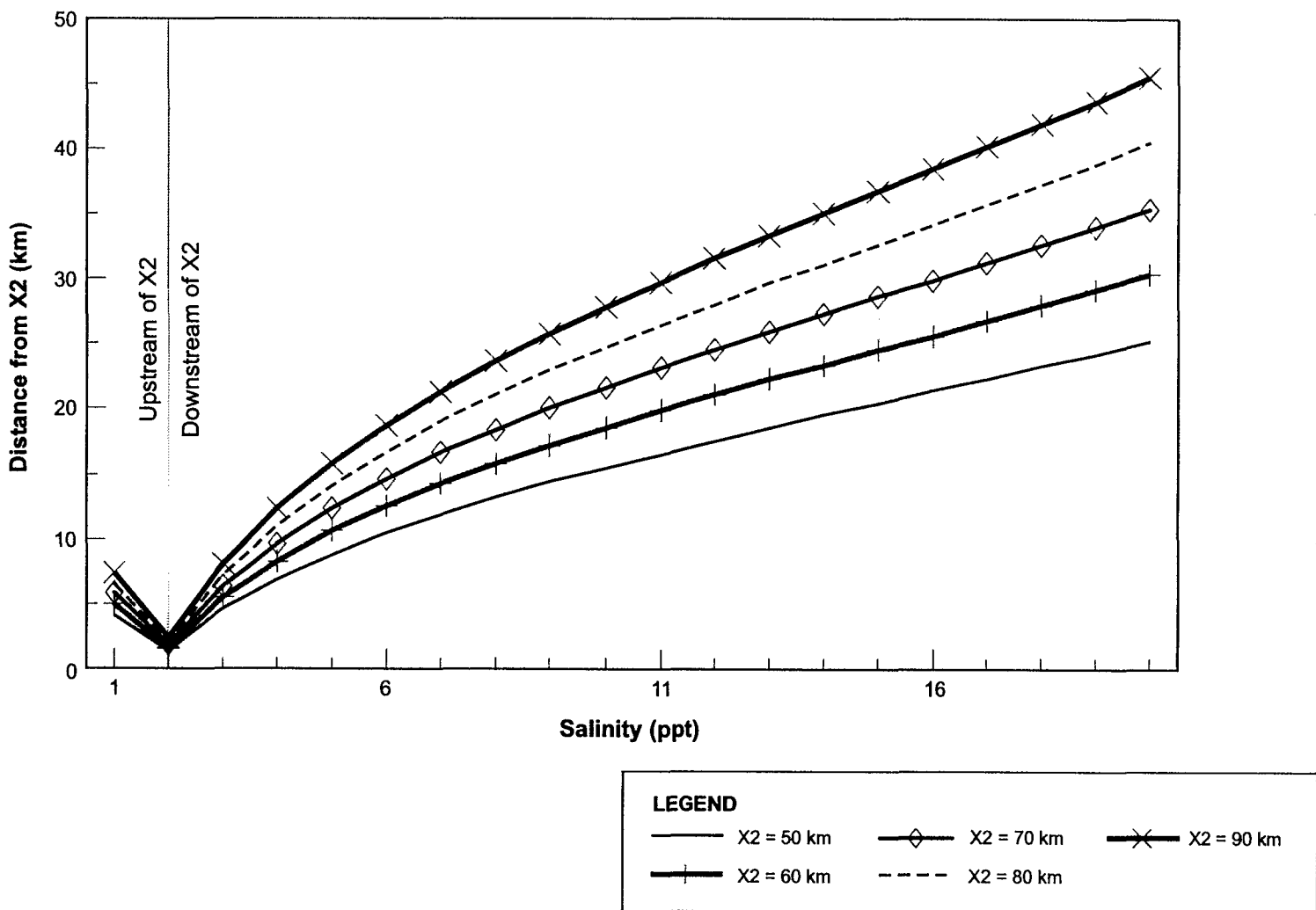


FIGURE III-16

ESTUARINE SALINITY RELATIVE TO X2 LOCATION AT FIVE DIFFERENT X2 SITES

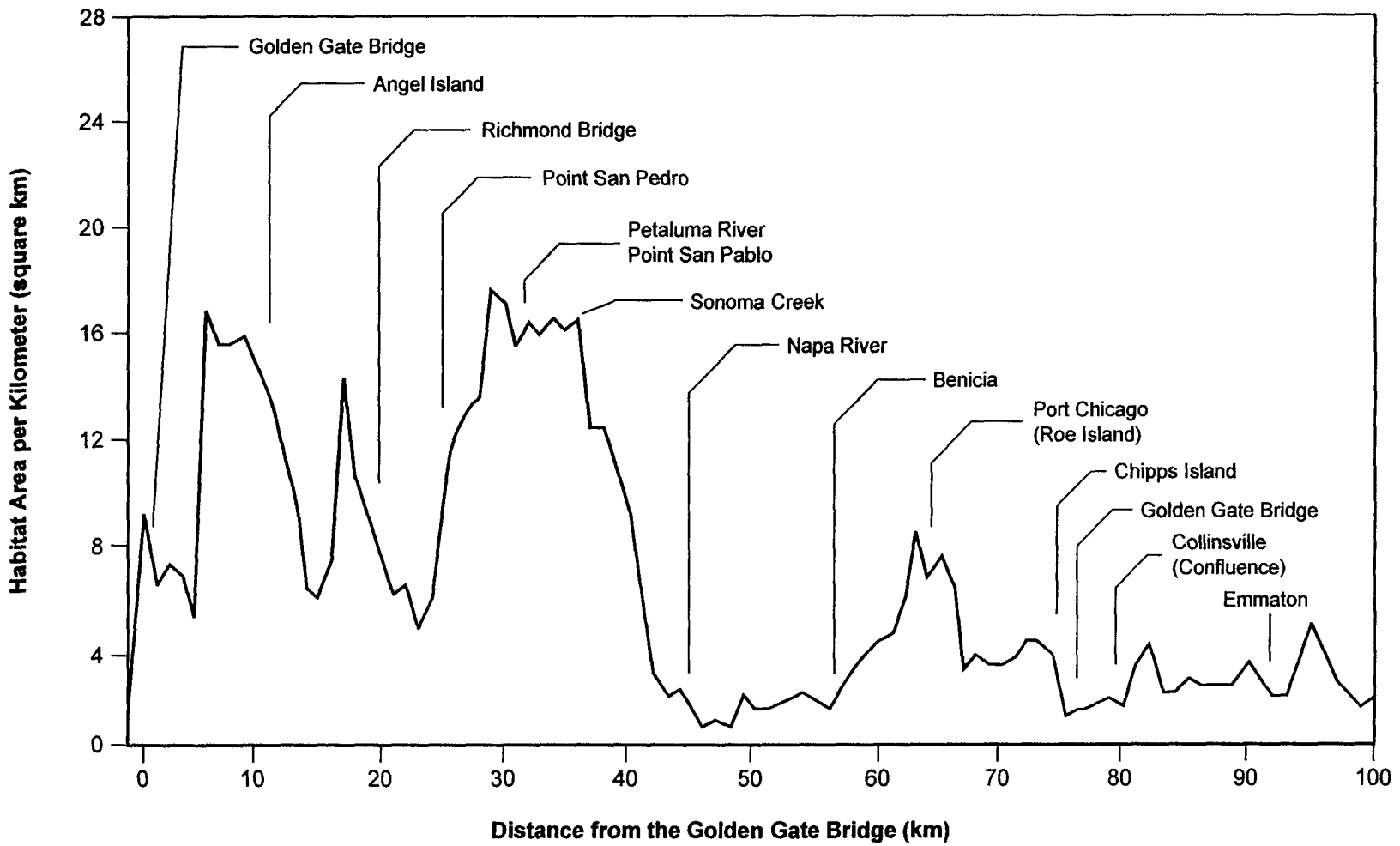


FIGURE III-17

ESTUARINE HABITAT AREA PER KILOMETER UPSTREAM OF THE GOLDEN GATE BRIDGE

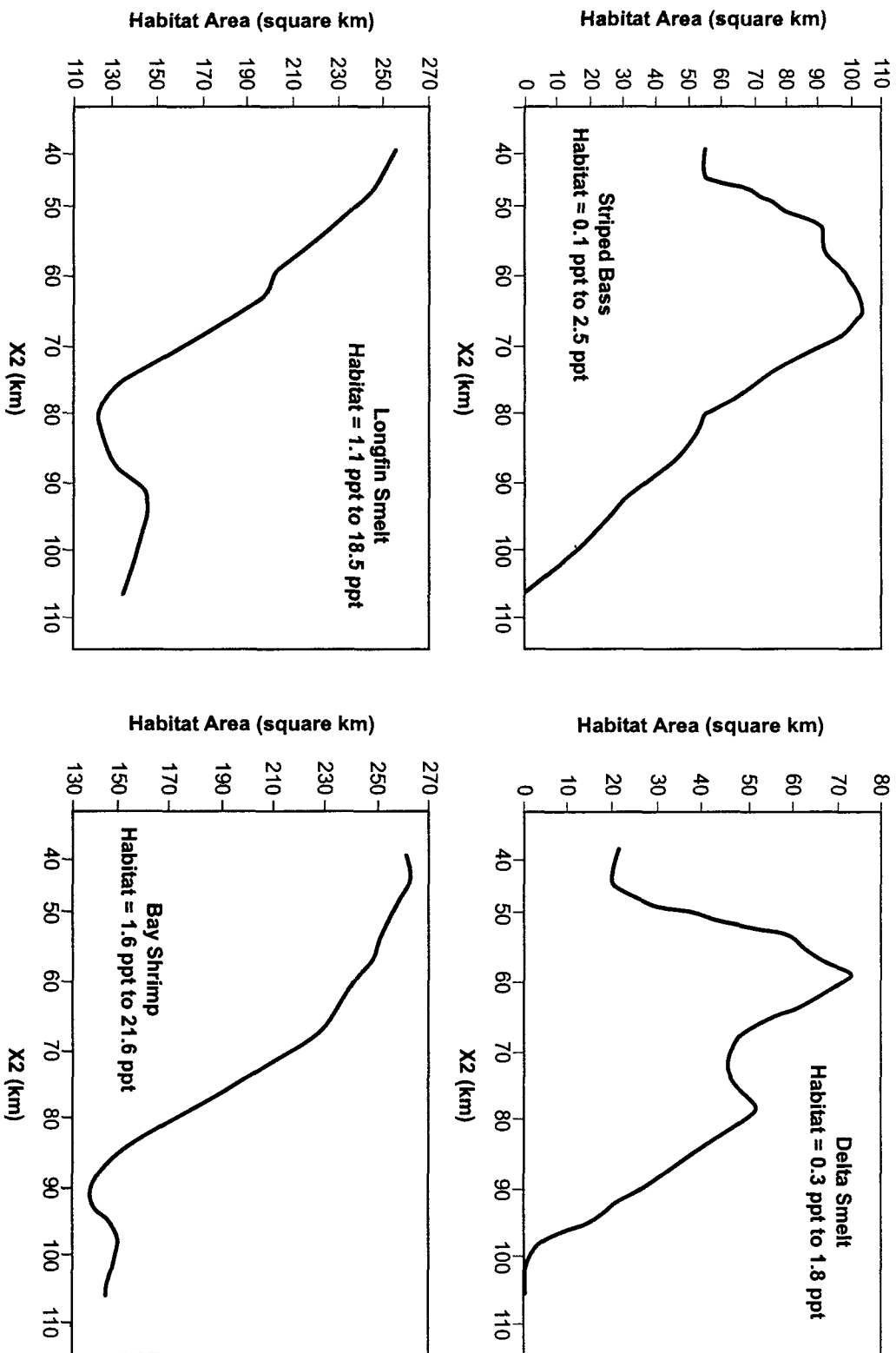


FIGURE III-18

**RELATIONSHIP BETWEEN OPTIMAL SALINITY HABITAT FOR FOUR DELTA SPECIES AND X2 LOCATION
(MEASURED AS DISTANCE UP-RIVER FROM THE GOLDEN GATE BRIDGE)**

Lake McClure, Millerton Lake, and San Luis Reservoir. The effect of changes in reservoir surface area are not evaluated for Camanche, Camp Far West, New Bullards Bar reservoirs, and other reservoirs that may be affected by implementation of the CVPIA.

Example Quantity and Quality of Habitat Analysis: Alternative 1, American River, Fall-Run Chinook Salmon. For this example analysis, the effects of habitat quantity and quality on fall-run chinook salmon in the American River under Alternative 1 are determined by comparing habitat conditions under Alternative 1 with those under the No-Action Alternative.

Data Sources. Habitat for fall-run chinook salmon on the American River is affected by flow, temperature, instream restoration, and riparian restoration. Alternative 1 includes both instream and riparian restoration actions for many watersheds, including the American River. Although a quantitative assessment of such actions is not possible because of the lack of sufficient detail in the CVPIA, they are considered qualitatively along with the other factors affecting habitat conditions. Actions that address habitat restoration are identified in PEIS Attachment F.

Average monthly river flow is simulated by Reclamation's operation models (as discussed in Attachment B). A sample of the 69-year simulation of monthly flow output from Reclamation's PROSIM and SANJASM models (American River under the No-Action Alternative and Alternative 1) is shown in Figure III-12.

Average monthly temperature is simulated by Reclamation's water temperature model (as discussed in Attachment B). The 69-year simulation of monthly water temperature output from Reclamation's water temperature model for this example (American River under the No-Action Alternative and Alternative 1) is shown in Figure III-7. For rivers for which simulated water temperature data are not available, flow and reservoir elevation provide an indication of potential water temperature effects (see discussion under Impact Assessment Methodology).

Step 1: Assessment of Quantity and Quality of Habitat during Months when Species Are Present. In general, quantity and quality of habitat would increase during all months. On the American River, Alternative 1 specifies enhancing spawning gravel, improving and protecting riparian habitat and instream cover, and restoring rearing habitat. Habitat restoration actions are assumed to provide benefits to habitat year round. However, the amount of habitat affected is not specified in the CVPIA actions.

Increased flow is assumed to increase the quantity and quality of habitat available. On the American River at Fair Oaks, flow increases relative to the No-Action Alternative from October through April and decreases relative to the No-Action Alternative during June through September (Figure III-12).

Reduced water temperature extends cool-water zones farther downstream, which provides additional habitat. In Figure III-7, water temperature at Fair Oaks increases relative to the No-Action Alternative during June, July, August, September, and November. Water temperature decreases relative to the No-Action Alternative during February and March. During April and May, clear patterns of temperature change relative to the No-Action Alternative are not apparent. During October, water temperature increases during years with relatively low water temperature and decreases during years with relatively high temperature.

As indicated in Table A-1 of Attachment A, chinook salmon are present in the American River during the life stages and months described under Water Temperature.

Spawning, incubation, rearing, and (to a much lesser extent) juvenile migration are affected by habitat conditions. The assessment of habitat conditions on migrating juveniles is included in the assessment for juvenile rearing (Table III-9). Adults are not included in the analysis of habitat conditions during their upstream migration. Therefore, habitat conditions during June, July, and September are not considered in the assessment of habitat quantity and quality for fall-run chinook salmon in the American River.

Step 2: Assessment of Biological Effects of Habitat Quantity and Quality by Month. Enhancing spawning gravel would provide additional habitat suitable for spawning and incubation. Improving riparian habitat and instream cover and restoring rearing habitat would increase suitable rearing habitat, provide additional refuge from predators, and provide microhabitat cooling. Thus, the increased habitat quantity and quality would benefit the spawning, incubating, and rearing life stages.

American River flow increases from October to April (Figure III-12), increasing habitat availability for chinook salmon. Spawning, incubation, fry rearing, and juvenile rearing would benefit from the higher flows. In contrast, reduced flows from June to September would decrease habitat availability, but fall-run chinook salmon are not present in the American River during that period.

Life stages affected by habitat quantity and quality would not be affected by increased water temperature during June, July, August, and September because they are not present in the American River during that period. Water temperatures from December through March are near optimal for all chinook salmon life stages, and temperature is not a factor in habitat availability. During most years in October, water temperature would decrease relative to conditions under the No-Action Alternative and would improve the quantity and quality of suitable habitat for spawning and incubation. During November and October of some years, water temperature would increase a few degrees, possibly eliminating some potential habitat from consideration as spawning and incubation habitat. However, the habitat restoration actions discussed previously may compensate for this habitat loss.

Step 3: Summary of Effects by Species and Overall Summary. The quantity and quality of habitat would increase in this example, benefiting critical early life stages, which in turn would benefit fall-run chinook salmon in the American River overall. Except for temperature conditions in October and November, all of the factors affecting habitat quantity and quality are beneficial, improving habitat conditions for fall-run chinook salmon in the American River. These beneficial habitat conditions contribute to an overall benefit for chinook salmon in the American River.

Food Web Support

Food web support is essential to maintain species diversity, abundance, and distribution within an aquatic community. Food web support includes nutrient availability, food production, and food availability. These components of food web support are affected by the action categories

including flow, instream diversion, habitat restoration, pollution inputs, and species interactions (Figure III-19).

Organisms that provide the food base for fish species are affected by the same environmental conditions critical to the maintenance and restoration of fish populations. The assessment methods previously discussed for the representative species are also applied to assess food web support. The methods for assessing food web support include the following assumptions:

- Reducing water surface-level fluctuation during critical periods of food organism life cycle, would increase the survival of these organisms in rivers and reservoirs.
- Increasing flow increases food organism habitat in rivers and in the Sacramento-San Joaquin Delta Estuary (i.e., related to estuarine salinity).
- Adding to and improving riparian and channel habitat increases food organism production in rivers and the Sacramento-San Joaquin Delta Estuary.
- Reducing pollutant concentrations increases food organism survival in all habitats.
- Reducing diversion during periods when food organisms are vulnerable to entrainment reduces their loss to entrainment in the Sacramento-San Joaquin Delta Estuary.
- Increasing reservoir surface level during critical periods in the life cycle of food organisms increases their availability.

Example Food Web Support Analysis: Alternative 1, American River, Fall-Run Chinook Salmon. For this example analysis, the effects of food web support on fall-run chinook salmon in the American River under Alternative 1 are determined by comparing environmental conditions under Alternative 1 with those under the No-Action Alternative.

Habitat for food web organisms on the American River is affected by flow, instream restoration, and riparian restoration (see Quantity and Quality of Habitat). Pollutants can disrupt the food chain by affecting food organisms, in much the same way that pollutants affect representative fish species (see Pollutants). Water surface-level fluctuations affect food organisms in the same way that representative species are affected (see Change in Water Surface Level). Diversion volume affects food web support by removing organisms and nutrients from the ecosystem (see Diversion).

Data Sources. Alternative 1 includes both instream and riparian restoration actions for many watersheds, including the American River. Although a quantitative assessment of such actions is not possible because of the lack of sufficient detail in the CVPIA, these actions are

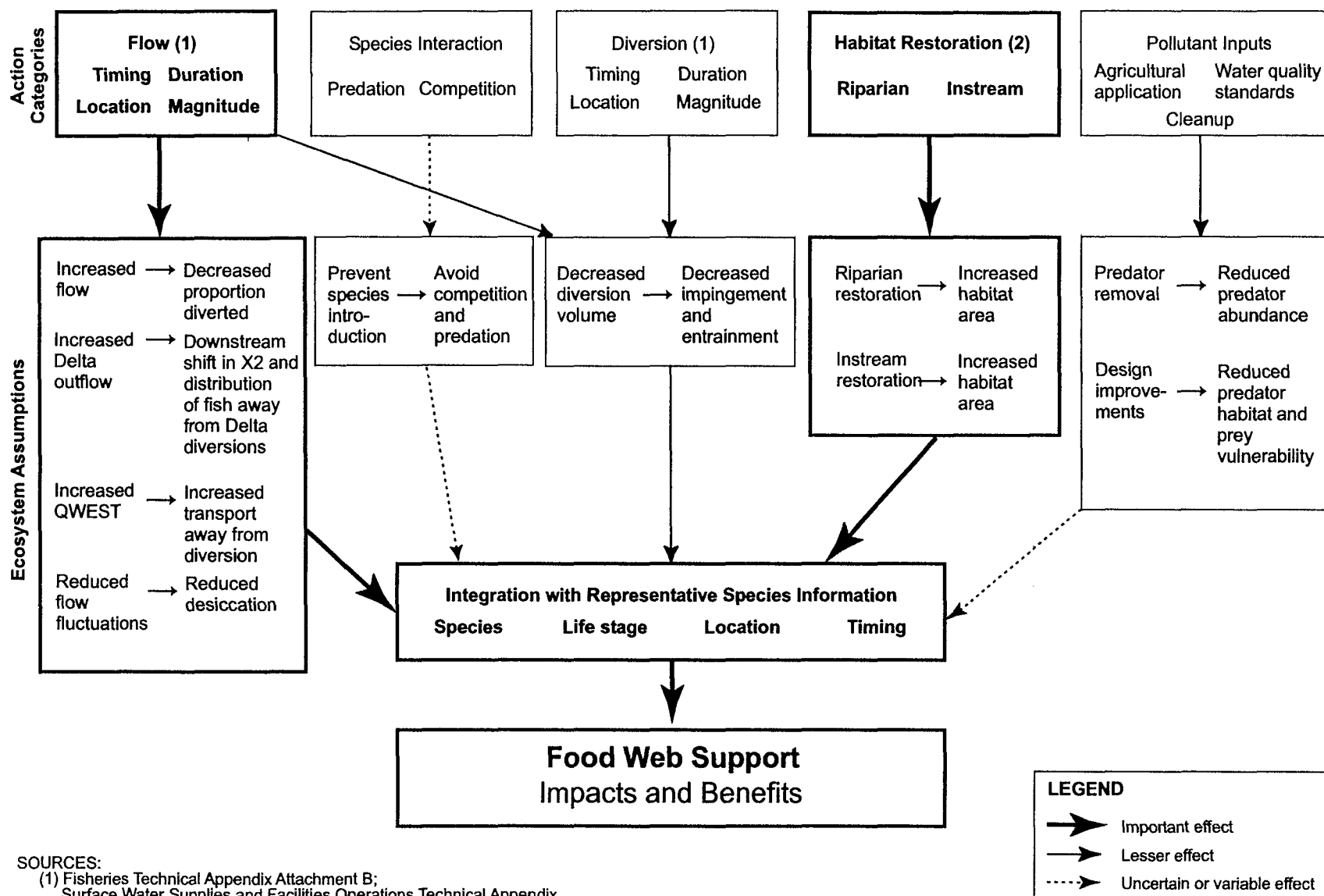


FIGURE III-19

PROPOSED ACTIONS AFFECTING FOOD WEB SUPPORT

considered qualitatively along with other factors affecting food web support. Actions that address habitat restoration are identified in PEIS Attachment F.

Pollutant levels are affected by several factors: pollutant input, cleanup of polluted sites, and possibly flow conditions. However, many actions related to water quality have not been defined in sufficient detail to allow a quantitative assessment of changes in pollutant levels, and the relationship between flow changes resulting from CVPIA actions and pollutant concentration cannot be determined quantitatively based on available data. For some watersheds, Alternative 1 directly addresses reducing pollutant input and cleaning up polluted sites, but this is not the case for the American River. Actions addressing water quality are identified in PEIS Attachment F.

River flow affects habitat conditions for food web support and possibly pollutant concentration. Average monthly river flow is simulated by Reclamation's operation models (as discussed in Attachment B). A sample of these data is shown in Figure III-12.

Daily and hourly surface level data are not available for assessing the effects of water surface level. CVPIA actions that minimize flow reductions over short periods are addressed under Alternative 1. Actions specifying reduced flow fluctuations are identified in PEIS Attachment F.

Average monthly diversion is simulated by Reclamation's operations models PROSIM and SANJASM (see Figure III-9).

Step 1: Assessment of Food Web Support during Months when Species Are Present. In general, restoration or enhancement actions would improve habitat conditions for all months. For the American River, Alternative 1 specifies improving and protecting riparian habitat and instream cover and restoring rearing habitat. Habitat restoration actions are assumed to provide benefits to food web organisms year round.

Alternative 1 has no actions that specifically address pollutants on the American River; however, flow changes on the American River could affect pollutant levels. The magnitude of these effects, as discussed under Pollutants, are unknown.

Flow conditions on the American River would be improved under Alternative 1. On the American River at Fair Oaks, flow increases relative to the No-Action Alternative from October through April (Figure III-12). Increased flow would improve habitat conditions for food web organisms (see Quantity and Quality of Habitat). Flow would decrease relative to the No-Action Alternative from June through September (Figure III-12), adversely affecting habitat conditions and resulting in reduced food web support.

Reduced flow fluctuations are identified for the American River under Alternative 1. Although the timing of these reductions are not identified, they are assumed to take place when they would have the greatest ecological benefit for chinook salmon.

In Figure III-9, for all months, the volume diverted under Alternative 1 is the same as the volume diverted under the No-Action Alternative (see Diversion). Therefore, no changes in food organism entrainment or nutrient loss attributable to diversion are expected.

As indicated in Table A-1 of Attachment A, chinook salmon are present in the American River during the life stages and months described under Water Temperature.

Rearing life stages and (to a much lesser extent) juvenile migration are affected by food web support. The assessment of food web support on migrating juveniles is included in the assessment for juvenile rearing (Table III-9). Adult migration, spawning, and egg incubation are not affected by changes in food web support, so June through December are not considered in the assessment of food web support for fall-run chinook salmon in the American River.

Step 2: Assessment of Biological Effects of Food Web Support by Month.

Improving riparian habitat and instream cover and restoring rearing habitat would increase the habitat available to support food web organisms. Therefore, rearing life stages would benefit from improved availability and productivity of food web organisms.

Increased flow on the American River from October to April (Figure III-12) would increase habitat availability for food web organisms. Thus, prey abundance would increase, resulting in greater food availability for rearing fall-run chinook salmon. However, reduced flow from June to September would reduce habitat for food organisms, adversely affecting their availability. However, fall-run chinook salmon would not be affected directly because they are not present in the American River during that period.

Reducing flow fluctuations on the American River under Alternative 1 would reduce the loss of food organisms through stranding and desiccation. Hence, rearing fall-run chinook salmon would benefit from increased availability of food organisms.

The volume of flow diverted from the American River under Alternative 1 would not change relative to the volume under the No-Action Alternative. Therefore, loss of food organisms to diversion would not differ from that under the No-Action Alternative.

Step 3: Summary of Effects by Species and Overall Summary. Food web support would benefit rearing juvenile chinook salmon, benefitting fall-run chinook salmon in the American River. All of the conditions that affect food web support during juvenile rearing are beneficial, and availability of food organisms in the American River would increase.

CHAPTER ORGANIZATION

The remainder of this chapter describes in detail the effects of alternatives 1 through 4 on the aquatic ecosystem. This description is organized by alternative. The discussion of the effects of each alternative is divided into three sections. The introduction describes those actions in each alternative that are expected to have effects on the aquatic ecosystem. Next are two sections that describe the effects on the aquatic ecosystem of each alternative, compared to the No-Action Alternative. The first section summarizes the effects by representative species. The second describes the same effects in more detail and is organized by environmental condition. This two-pronged assessment allows the reader to easily find information regarding the effects of each alternative on a particular species or environmental condition.

NO-ACTION ALTERNATIVE

The No-Action Alternative is the condition with which alternatives 1 through 4 are compared for the PEIS alternatives analysis. The No-Action Alternative represents conditions in the future assuming a projected 2022 level of development without implementation of the CVPIA. The No-Action Alternative assumes the operation of existing facilities and future facilities that are certain to be constructed by 2022. The No-Action Alternative assumes that these water resource facilities will be operated in accordance with operating rules and criteria that were in effect or being developed as of October 1992 when the CVPIA was adopted. The most important criteria affecting operations of CVP facilities are contained in:

- the Coordinated Operations Agreement
- the Bay-Delta Plan Accord as defined in the State Water Resources Control Board (SWRCB) May 1995 Draft Water Quality Control Plan
- the 1993 Winter-Run Chinook Salmon Biological Opinion as amended in 1995 by the National Marine Fisheries Service
- minimum flow requirements on the American River maintained per a historical Reclamation practice known as modified Decision 1400
- 1987 agreements between Reclamation and DFG regarding Stanislaus River minimum streamflows of 155,700 acre-feet in non-critical years and 98,300 acre-feet in critical years
- SWRCB Decision 1422 (D-1422), which requires New Melones Reservoir releases to meet defined water quality standards
- SWRCB Water Rights Order 90-5

Other CVP system operations are consistent with the criteria defined in the Long-Term Central Valley Project Operations Criteria and Plan CVP-OCAP (October 1992).

The No-Action Alternative also incorporates those provisions of the CVPIA that were previously identified as necessary for protecting winter-run chinook salmon (i.e., the temperature control structure at Shasta Lake and operational changes at RBDD and the DCC). Most CVPIA provisions and restoration actions are not included in the No-Action Alternative.

RESPONSE TO ENVIRONMENTAL CONDITIONS

Under the No-Action Alternative, water temperatures in the upper Sacramento River (below Shasta Lake) would be maintained by the temperature control structure at Shasta Lake in compliance with the 1993 Winter-Run Chinook Salmon Biological Opinion.

Under the No-Action Alternative, only fish screens at RBDD, ACID, and GCID would be improved. Both changes in flow and water quality would affect mortality attributable to

pollutants. Increased flows in the Sacramento River at Keswick Reservoir and RBDD could dilute pollutants that could affect winter-run chinook salmon.

Under the No-Action Alternative, modifying the ACID diversion dam and raising RBDD gates between September 15 and May 15 should help reduce predation at these locations. Improved fish screens and bypass flows are expected to occur under the No-Action Alternative at RBDD, ACID, and GCID. Increased mortality may occur when flow fluctuation causes stranding and juvenile fish are subjected to increased predation.

Raising RBDD gates between September 15 and May 15, and the modifying the ACID diversion dam operations should facilitate the passage of juvenile chinook salmon and steelhead trout and possibly also juvenile sturgeon under the No-Action Alternative. In the Delta, operation of the DCC and Georgiana Slough flow division channels would continue to transport striped bass eggs and larvae, and migrating juvenile salmonids in proportion to the division of Sacramento River flow entering these channels. These fish are exposed to increased mortality compared to eggs, larvae, and juveniles that continue down the Sacramento River. Under the No-Action Alternative, the DCC would be closed up to 45 days between November and January, when juvenile salmon enter the Delta, or when flow or turbidity changes trigger salmon migration. The DCC is closed from February through April. Closure of the DCC also would be maximized during May and June when Sacramento River chinook salmon are abundant.

Under the No-Action Alternative, migrating adult chinook salmon would continue to be attracted to inappropriate habitat in the San Joaquin River above the mouth of the Merced River, into the Colusa Basin Drain, and into unsuitable habitat in Cottonwood Creek. To reduce adverse attraction, an escape channel for trapped adult chinook salmon and steelhead trout from the Keswick Reservoir stilling basin to the Sacramento River would be constructed under the No-Action Alternative.

Under the No-Action Alternative, raising the gates at RBDD between September 15 and May 15 and modifying ACID diversion dam operations would increase access to upstream habitat.

ALTERNATIVE 1

Alternative 1 includes habitat improvements based on components of the CVPIA, including actions related to flow, structures, habitat, and species management (Figure III-20). Implementation of Alternative 1 would benefit all representative fish species by improving environmental conditions and increasing habitat availability (Figures III-21 and III-22).

In general, flows improve fish habitat under Alternative 1 compared to the No-Action Alternative (Table III-4). Flow needs are based on flow recommendations developed by the Service as part of the Anadromous Fish Restoration Program (PEIS Attachment G). The ability to meet flow needs under Alternative 1 is determined by base flow operations and the availability of CVP water dedicated to fish restoration. Water temperatures also respond to reservoir reoperation and changes in the volume and timing of river flows implemented under Alternative 1. Beneficial impacts that accrue to aquatic species from flow-related actions include reduced water

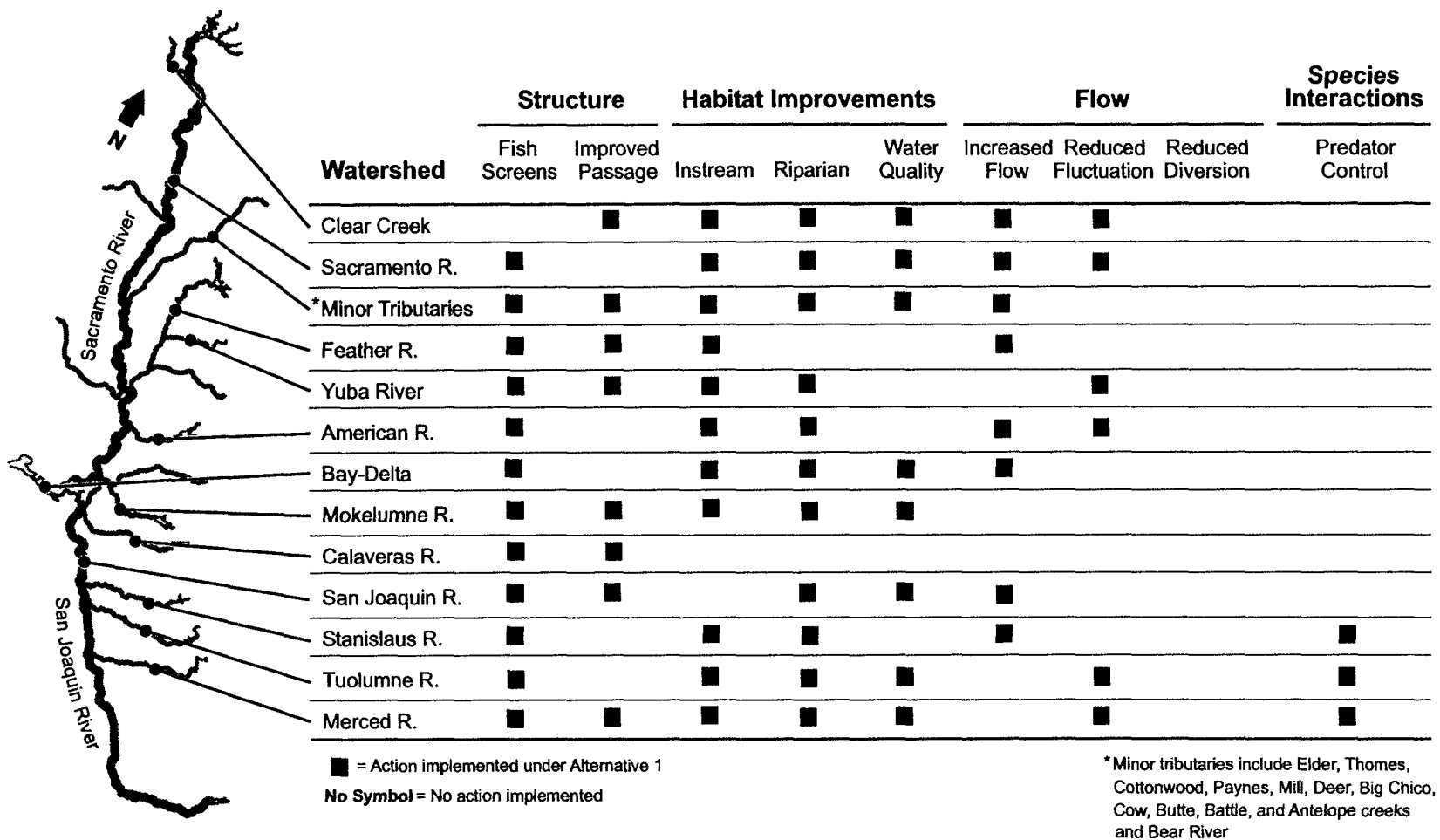


FIGURE III-20

CVPIA ACTIONS IMPLEMENTED TO BENEFIT FISH
AND AQUATIC RESOURCES UNDER ALTERNATIVE 1

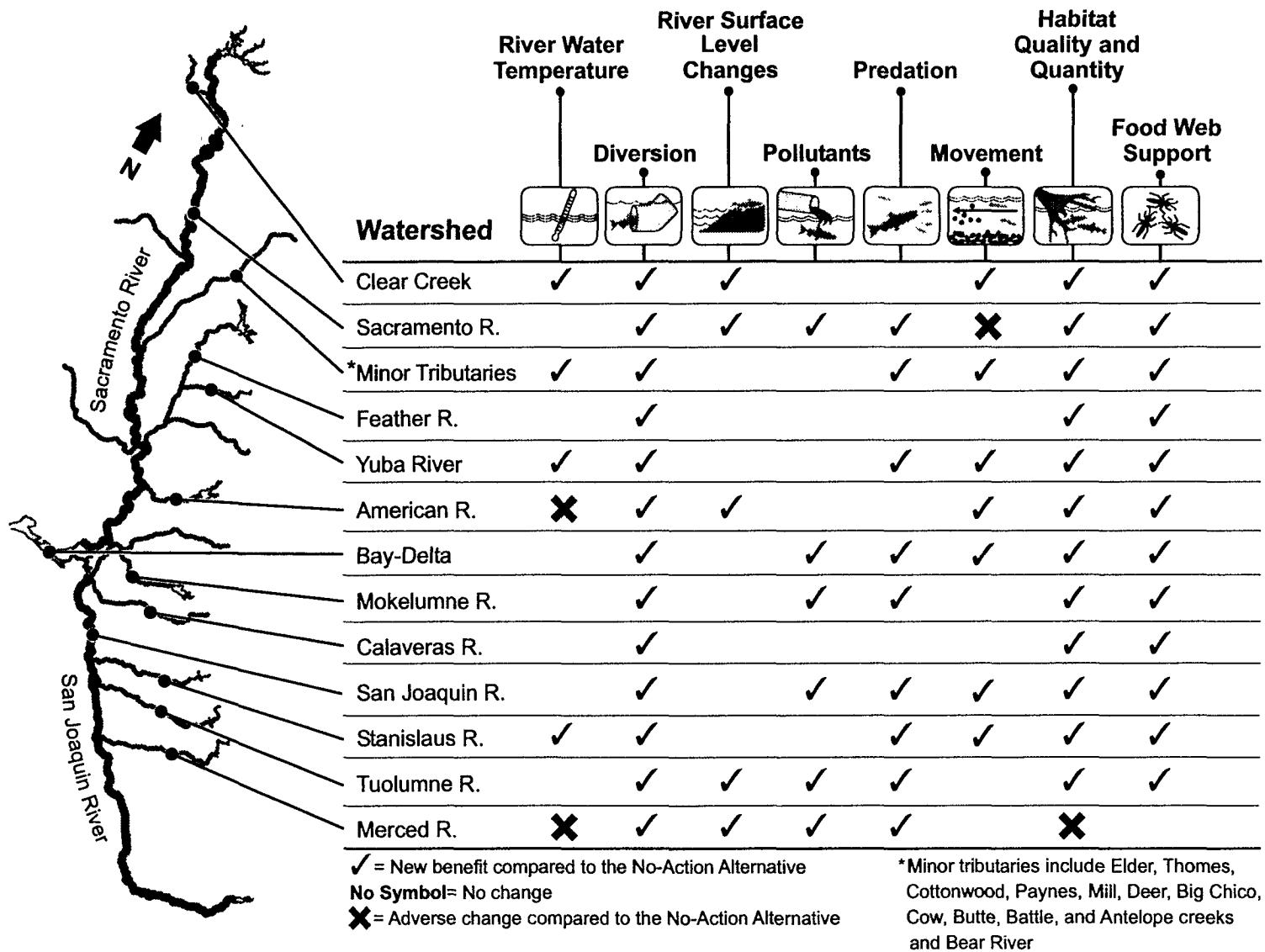


FIGURE III-21

CHANGES IN ENVIRONMENTAL CONDITIONS AFFECTING FISH POPULATIONS
UNDER ALTERNATIVE 1 COMPARED TO THE NO-ACTION ALTERNATIVE

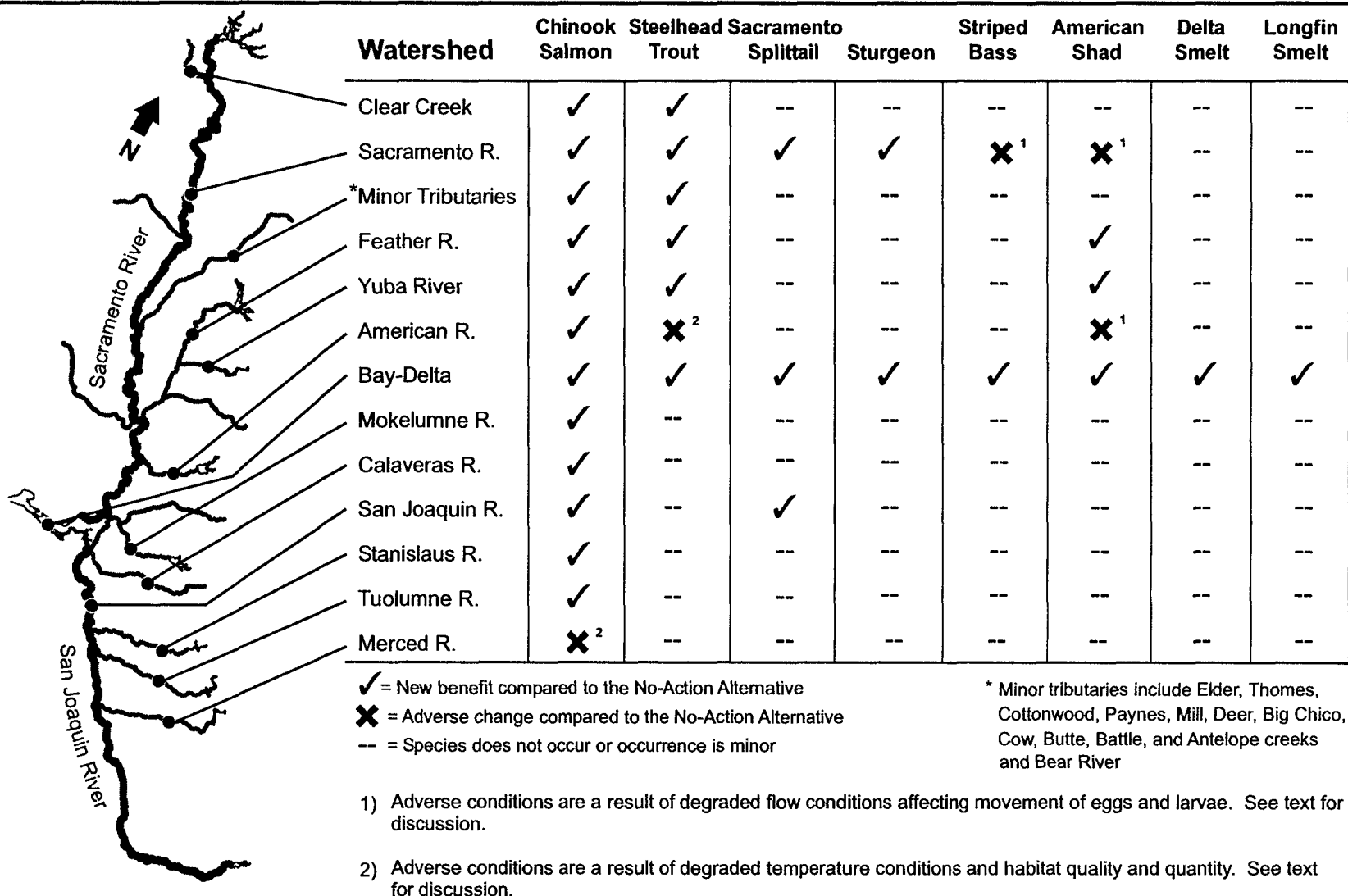


FIGURE III-22

**BENEFICIAL AND ADVERSE CHANGES TO FISH SPECIES
UNDER ALTERNATIVE 1 COMPARED TO THE NO-ACTION ALTERNATIVE**

temperature, diversion, and surface level change; improved conditions affecting movement; increased habitat quantity and quality; and increased food web support.

Alternative 1 also includes structural changes, such as the removal, construction, and modification of barriers; fish screen improvements; and the construction and reoperation of temperature control structures (Table III-2 and PEIS Attachment F). Fish screen improvements for Alternative 1 include constructing new fish screens, improving bypass flows, reducing handling mortality (for salvaged fish), and reducing predation that may be attributable to structures and flow conditions associated with diversions (Table III-2). Structural changes would improve water temperature, diversion conditions, and conditions affecting movement. Structural changes would increase access to habitat and food web support for aquatic species.

Habitat restoration actions with potential to be implemented under the CVPIA include restoring riparian habitat, shallow water habitat in the Delta, meander corridors, and salmonid rearing and spawning habitat. Watershed management programs and programs that reduce pollutant inputs are also included (Table III-3 and PEIS). Habitat restoration actions would reduce losses due to adverse water temperature and pollutants and would increase suitable habitat and food web support for aquatic species.

Species management actions are not clearly defined under the CVPIA. Therefore, changes in environmental conditions and the resultant beneficial and adverse impacts cannot be determined with available information. Species management actions include rehabilitating and expanding Coleman National Fish Hatchery; supporting DFG actions to augment the striped bass population; and, possibly, removing predators associated with diversions, barriers, gravel ponds, and other human-induced conditions.

RESPONSE BY REPRESENTATIVE SPECIES

Compared to the No-Action Alternative, actions implemented under Alternative 1 would benefit all of the representative species (Figure III-22). The actions result in beneficial changes for most environmental conditions within each watershed, reduce loss of individuals, and increase habitat availability and quality (Figure III-21). The actions are expected to increase the geographic distribution and abundance of most representative species compared to the No-Action Alternative. The CVPIA actions should also increase the likelihood that species will survive and maintain productivity during natural and human-caused changes in future environmental conditions.

The following sections describe the responses of each representative species (based on applicable environmental conditions) to the CVPIA and restoration actions included in Alternative 1. Specific information for each environmental condition is provided in the section Response by Environmental Condition.

Chinook Salmon

Effects on chinook salmon are discussed separately for fall, late fall, winter, and spring runs. All Central Valley streams would benefit from habitat restoration actions, improved flows, or the combination of both. Therefore, the chinook salmon runs using the Central Valley streams identified in Figure III-22 would respond to the actions implemented in Alternative 1 compared to the No-Action Alternative. Alternative 1 habitat restoration actions on the Merced River would not improve overall habitat quality and quantity as a result of adverse water temperature conditions (Figure III-21).

Fall-Run Chinook Salmon. Fall-run chinook salmon occur in all the major rivers and streams of the Sacramento and San Joaquin River basins and have the most extensive geographic distribution of all the representative species (Figure III-3). Implementation of the CVPIA actions under Alternative 1 would improve habitat conditions for fall-run chinook salmon compared to conditions under the No-Action Alternative.

In the Sacramento River, Clear Creek, Feather River, Yuba River, Bear River, American River, and minor tributaries, increased habitat quantity and quality and food web support (Figure III-21) would benefit eggs, larvae, and juvenile fall-run chinook salmon using those streams. Removal of barriers and other improvements to fish passage would increase access to habitat in tributary streams, including Clear Creek and the Yuba River. Increased suitable habitat and food web support could result from actions that would restore spawning substrate, rearing habitat, riparian habitat, and river meander dynamics. Increased flow during spawning and rearing periods in the Sacramento River, Clear Creek, and the American River could provide additional spawning and rearing habitat.

Reduced pollutant levels and improvements related to diversion, water surface-level change, and movement (Figure III-21) would also benefit adult, egg, larval, and juvenile chinook salmon. Loss of juveniles to diversions would be reduced by fish screen improvements on the Sacramento River, Yuba River, Clear Creek, and minor tributaries. The removal of diversions would reduce the loss of juveniles in some minor tributary streams. CVPIA actions that result in changes in reservoir operations would reduce the loss of eggs, fry, and juveniles to short-term water surface-level change in the Sacramento, Yuba, and American rivers. The removal of barriers and other improvements to fish passage would reduce the loss of juveniles attributable to conditions impeding movement on tributary streams, including Clear Creek and the Yuba River. Barriers constructed to block access to unproductive habitat on some tributary streams (i.e., the San Joaquin River upstream of the Merced River) would enhance movement of adult fall-run chinook salmon.

Not all actions implemented under Alternative 1 would benefit fall-run chinook salmon in the Sacramento River basin. Simulated Sacramento River flow is lower than flow under the No-Action Alternative during May through September. From April through September, water temperature would increase and would exceed optimal levels in habitat downstream of RBDD from May through September. Fall-run juveniles could be affected during May and June and migrating adults could be affected during August and September. Although losses to adverse temperature could increase, water temperature in upstream reaches would remain within the optimal range and water temperature farther downstream would not be affected. Less rearing

habitat, however, would be available under Alternative 1. Compared to the No-Action Alternative, lower flow could also reduce rearing habitat and increase pollutant concentrations, primarily affecting juveniles. The effects would be countered by habitat restoration actions that reduce pollutant concentration through reduced input and increase habitat through restoration.

In the American River, elevated water temperature compared to the No-Action Alternative (Figure III-21) could increase spawning and egg incubation losses in October and November. Restoration actions for reoperating or reconfiguring the multilevel release shutters could improve water temperature compared to conditions indicated by the simulated temperature.

For the San Joaquin River and its tributaries, fall-run chinook salmon would benefit from increased habitat and food web support (Figure III-21) resulting from actions that would restore spawning substrate, rearing habitat, and riparian habitat. Increased flow and reduced water temperature during juvenile rearing would provide additional habitat in the Stanislaus River.

Changes in ecosystem conditions such as reduced water temperature, diversion volumes, water surface-level change, pollutant levels, and predation and improved conditions affecting movement (Figure III-21) would cumulatively benefit all life stages of fall-run chinook salmon in the San Joaquin River basin. Water temperature would be reduced by increased flow and cooler water in the Stanislaus River during April and May, benefiting juvenile fall-run chinook salmon.

Fish screen improvements on the San Joaquin River and its tributaries (Figure III-20) would reduce the loss of juveniles to diversions. CVPIA actions address reservoir operations and would reduce the loss of eggs, fry, and juveniles to short-term water surface-level change in the Tuolumne and Merced rivers. Construction of barriers to block access to unproductive habitat on the mainstem San Joaquin River upstream of the Merced River would improve conditions affecting movement for adult fall-run chinook salmon. Predation may be reduced by isolating existing ponds from the main river flow.

Adverse water temperatures on the Stanislaus and Merced rivers would occur under Alternative 1 (Figure III-21). On the Stanislaus River, simulated operations under Alternative 1 indicate that increased water temperature could increase fish mortality during spawning and incubation in October and November. Through operation of reservoir releases, these relatively small increases in simulated water temperatures would be reduced to meet the October 15 target of 56 degrees Fahrenheit. Adverse water temperatures on the Merced River would occur during April and May as a result of reduced reservoir storage and river flow under Alternative 1, especially during dry years. The availability of juvenile rearing habitat would be reduced and additional mortality from increased water temperature could occur.

In the Sacramento-San Joaquin Delta Estuary, fall-run chinook salmon would benefit from lower diversion volumes, reduced pollutant inputs, improved conditions affecting movement, increases in the amount of suitable habitat available, and increases in food web support (Figure III-21). Losses to diversions would be reduced by fish screen improvements and by reduced Delta diversion during May and June. Increases in suitable habitat availability and food web support could result from actions that would restore shallow water and riparian habitats, benefiting juveniles during their temporary residence and migration through the Delta. For juvenile fall-run migrating down the Sacramento River, increased movement into the central Delta through the

DCC and Georgiana Slough could occur during June, potentially increasing diversion-related mortality. However, a higher QWEST during April, May, and June would encourage movement of juvenile salmon out of the central and south Delta and toward Suisun Bay, thereby reducing their exposure to diversions; this includes juvenile fall-run chinook salmon originating from the Sacramento, San Joaquin, and Mokelumne rivers.

Late Fall-Run Chinook Salmon. Implementation of the CVPIA actions under Alternative 1 would improve habitat conditions for late fall-run chinook salmon compared to conditions under the No-Action Alternative. The greatest beneficial impacts accrue in riverine habitat used by late fall-run chinook salmon in the Sacramento River and in Clear Creek. Eggs, larvae, and juveniles would benefit from increased suitable habitat and food web support and from reduced pollutant inputs, diversion volumes, and water surface level change (Figure III-21). Increases in suitable habitat and food web support could result from actions that would restore spawning substrate, rearing habitat, riparian habitat, and river meander dynamics. In addition, increased flow during spawning and early rearing periods in the Sacramento River, and more extensively in Clear Creek, could increase availability of spawning and rearing habitat. Losses to diversions would be reduced by fish screen improvements.

In the Sacramento-San Joaquin Delta Estuary, juvenile late fall-run chinook salmon would benefit from lower diversions and reduced pollutant levels, improved conditions affecting movement, and increased suitable habitat availability and food web support (Figure III-21). Losses to diversions would be reduced by fish screen improvements and by reduced Delta diversion during May and June. Increases in the quantity and quality of habitat and food web support result from actions that would restore shallow water and riparian habitats that would benefit juveniles during temporary residence and migration through the Delta.

Although the actions under Alternative 1 would benefit late fall-run chinook salmon overall, some CVPIA actions could have adverse impacts. Simulated Sacramento River flow is lower than flow under the No-Action Alternative from May through September. Flow reduction could reduce habitat and increase pollutant concentrations, affecting juveniles. However, the effects would be countered by habitat restoration actions that reduce pollutant inputs and increase habitat through restoration actions.

Winter-Run Chinook Salmon. Similar to late fall-run, winter-run chinook salmon would benefit from implementation of Alternative 1. Beneficial impacts would occur in the Sacramento River and in the Sacramento-San Joaquin River Delta. Additional beneficial impacts could occur from maintaining habitat conditions essential for winter-run chinook salmon to complete the freshwater portion of their life cycle in the Calaveras River. CVPIA actions on the Calaveras River are assumed to benefit winter-run, but the available information does not support further analysis in this PEIS.

The greatest beneficial impacts to winter-run chinook salmon accrue in riverine habitat in the Sacramento River. Spawning and rearing life stages would benefit from increased quantity and quality of habitat and food web support and from reductions in pollutants, diversion, and water surface-level change (Figure III-21). Increased suitable habitat availability and food web support result from actions that would restore spawning substrate, rearing habitat, riparian habitat, and river meander dynamics. Losses to diversions would be reduced by fish screen improvements.

In the Sacramento-San Joaquin Delta Estuary, juvenile winter-run chinook salmon would benefit from reductions in pollutants and diversion and from increases in habitat quantity and quality and food web support (Figure III-21). Losses to diversions would be reduced by fish screen improvements. Increases in habitat availability and food web support could result from actions that would restore shallow water and riparian habitats that would benefit juveniles during temporary residence and migration through the Delta.

Although the actions under Alternative 1 would benefit winter-run chinook salmon overall, some CVPIA actions could have adverse impacts. Simulated Sacramento River flow is lower under Alternative 1 than flow under the No-Action Alternative from June through September. Flow reduction could increase pollutant concentrations, affecting eggs and juveniles. However, the effects would be lessened by habitat restoration actions that lower pollutant inputs. In the Delta, movement and diversion losses under Alternative 1 may increase in response to reduced QWEST and increased diversion during December through February. Adverse effects would be offset by fish screen improvements and beneficial effects during other months.

Spring-Run Chinook Salmon. Similar to the other runs, spring-run chinook salmon would also benefit from implementation of Alternative 1. Beneficial impacts would occur in the Sacramento River, in the tributaries to the Sacramento River (e.g., Feather River, Clear Creek, Mill Creek, Deer Creek, Battle Creek), and in the Sacramento-San Joaquin River Delta. The greatest beneficial impacts accrue in riverine habitat in the Sacramento River and its tributaries. Spawning-incubation and rearing life stages benefit from increases in the availability of suitable habitat and food web support; reductions in pollutant levels, diversion volumes, and water surface-level change; and improved movement conditions (Figure III-21). Increases in the quantity and quality of habitat and food web support could result from actions that would restore spawning substrate, rearing habitat, riparian habitat, and river meander dynamics. Improved passage over barriers and removal of barriers on minor tributary streams would improve access to underutilized habitat. In addition, increased flow in Clear Creek could result in more spawning and rearing habitat. On the Sacramento River and in the minor tributary streams, losses to diversions would be reduced by fish screen improvements and the removal of diversions. The removal and modification of dams on the minor tributaries would improve conditions affecting movement for migrating juveniles.

In the Sacramento-San Joaquin Delta Estuary, juvenile spring run would benefit from reduced pollutant levels and diversion and from increased suitable habitat and food web support (Figure III-21). Losses to diversions would be reduced by fish screen improvements. Increased suitable habitat and food web support could result from actions that would restore shallow water and riparian habitats that would benefit juveniles during their temporary residence and migration through the Delta.

Although the actions under Alternative 1 would benefit spring-run chinook salmon overall, some CVPIA actions could have adverse impacts. Simulated Sacramento River flow is lower under Alternative 1 than flow under the No-Action Alternative from June through September. Lower flow, compared to the No-Action Alternative, could reduce rearing habitat availability and increase pollutant concentrations, affecting juveniles. However, the effects would be offset by habitat restoration actions that lower pollutant inputs and increasing the amount of habitat. In the Delta, adverse conditions affecting movement and diversion may reduce survival under

Alternative 1 in response to reduced QWEST and increased diversion from November through February. Adverse effects would be offset by fish screen improvements and beneficial effects during other months.

Steelhead Trout

Steelhead trout is a cool-water species with needs most similar to the late fall- and spring-run chinook salmon runs previously discussed. Implementation of the CVPIA actions under Alternative 1 would improve habitat conditions for steelhead trout compared to conditions under the No-Action Alternative. Beneficial impacts would occur in the Sacramento River, in the tributaries to the Sacramento River (e.g., Feather River, Clear Creek, Mill Creek, Deer Creek, Battle Creek), and in the Sacramento-San Joaquin River Delta (Figure III-22). The greatest beneficial impacts accrue in riverine habitat in the Sacramento River and its tributaries. Spawning-incubation and rearing life stages would benefit from improved movement, quantity and quality of habitat, and food web support and from reduced pollutant levels, diversion, and water surface-level change (Figure III-21). Improved conditions affecting movement would result from improved passage over barriers, removal of barriers on small tributary streams, and removal and modification of dams on minor tributaries and the Yuba River. Increases in the amount of suitable habitat and food web support could result from actions that would restore spawning substrate, rearing habitat, riparian habitat, river meander dynamics, and actions improving access to habitat. In addition, increased flow in Clear Creek could increase the availability of spawning and rearing habitats. Diversion-related mortality would be reduced by fish screen improvements and the removal of diversions.

In the Sacramento-San Joaquin Delta Estuary, juvenile steelhead would benefit from reduced pollutant levels and diversion and from increases in the quantity and quality of habitat and food web support (Figure III-21). Losses to diversions would be reduced by fish screen improvements and by reduced Delta diversion during April and May. Increases in the quantity and quality of habitat and food web support could result from actions that would restore shallow water and riparian habitats that would benefit juveniles during their temporary residence and migration through the Delta.

Although the actions under Alternative 1 would benefit steelhead trout overall, some CVPIA actions would have adverse impacts. Simulated Sacramento River flow under Alternative 1 is lower than flow under the No-Action Alternative from June through September. Flow reduction would reduce habitat quantity and quality and increase pollutant concentrations, affecting juveniles. However, the effects would be offset by habitat restoration actions that lower pollutant inputs and increase the amount of habitat. In the American River, reduced flow and operations changes from June through September would increase losses from adverse temperature and reduce habitat. Restoration actions (e.g., riparian and channel habitat restoration) are unlikely to lessen the effects of reduced flow and elevated water temperature on juvenile steelhead rearing in the American River (Figure III-21). In the Delta, adverse conditions affecting movement and diversion losses under Alternative 1 may increase in response to reduced QWEST and increased diversion during January and February, but adverse effects would be offset by fish screen improvements and beneficial effects in the Delta during other months.

Sturgeon

The assessment of impacts on sturgeon encompasses both white and green sturgeon species. Implementation of actions under Alternative 1 would benefit sturgeon (Figure III-22) through improved habitat conditions compared to conditions under the No-Action Alternative. The population would benefit most from increases in the quantity and quality of habitat and food web support (Figure III-21), derived primarily from restoration of riparian habitat, river meanders, and shallow water habitat in the Delta. Reduced pollutant levels would also benefit sturgeon, especially considering their longevity and residence in the Sacramento-San Joaquin Delta Estuary.

American Shad

American shad would benefit from some CVPIA actions implemented under Alternative 1 (Figure III-22). Compared to the No-Action Alternative, beneficial impacts would accrue during all life stages in response to reductions in pollutant levels and diversions; and increases in the quantity and quality of habitat and food web support (Figure III-21). Juvenile American shad would benefit from fish screen improvements that would reduce losses to diversions. In addition, reduced Delta diversions from April through July would reduce the amount of egg, larval, and juvenile shad entrainment occurring in Delta habitats. Restoration of riparian habitat and river meanders would increase habitat and food availability for juvenile American shad rearing in the Sacramento and Feather rivers. Restoration of shallow water habitat in the Delta would benefit juvenile American shad rearing in the Delta.

Although American shad would benefit from the total package of CVPIA actions implemented under Alternative 1, not all actions foster beneficial responses. Reduced flow in the Sacramento and American rivers during May, June, and July may increase the mortality of eggs and larvae (Figure II-21). Delta diversions from September through November would generally increase and may increase entrainment of outmigrant juvenile American shad. Fish screens and improved salvage operations implemented under the CVPIA, however, would reduce the loss of affected fish. In addition, food web support may be reduced compared to the No-Action Alternative. The upstream shift in estuarine salinity caused by reduced Delta outflow from July through November potentially affects food availability during shad outmigration from September through November. CVPIA actions that lessen adverse effects of reduced Delta outflow on food availability include habitat restoration actions in the Delta and reduced pollutant levels.

Striped Bass

Simulated data for the Sacramento River indicate reduced flows during April, May and June, which adversely affect the transport of eggs and larvae and striped bass populations (Figure III-22). Many actions implemented under Alternative 1 would benefit striped bass. Beneficial impacts would accrue during the egg, larval, and juvenile rearing life stages in response to reductions in pollutant levels and diversions, increases in the quantity and quality of habitat, and improved food web support (Figure III-21). Adult striped bass would benefit from reduced levels of pollutants and increased habitat and food web support.

Juvenile striped bass would benefit from fish screen improvements that would reduce losses to diversion. In addition, reduced Delta diversions from April through August would reduce losses

of egg, larval, and juvenile striped bass. Conditions affecting movement would also be improved compared to the No-Action Alternative, primarily in response to a higher QWEST from May through August attracting organisms toward Suisun Bay. An upstream shift in estuarine salinity during July and August, however, would moderate the potential benefit of a higher QWEST. Restoration of shallow water and riparian habitats in the Delta would also benefit juvenile striped bass by increasing habitat availability and food web support.

Striped bass would be adversely affected by poor conditions affecting movement, increased diversion, and reductions in the quantity and quality of habitat. Reduced flow in the Sacramento River during the egg and larval life stages (May and June) may increase mortality because of insufficient movement downstream (Figure III-22). The contribution of Sacramento River spawners (greater than 50 percent of the population) to year class abundance would be adversely affected. In the Delta, the proportion of eggs entering the central Delta from the Sacramento River through the DCC would increase during June and possibly July. Habitat in the central Delta is generally less productive than habitat further downstream. As noted above, however, diversion and QWEST would be reduced during May through August and would offset the adverse DCC transport effects.

CVP diversions from October through January would generally increase and may increase juvenile striped bass mortality resulting from entrainment, impingement, and reduced movement toward Suisun Bay. Less flow toward Suisun Bay and increased flow toward the SWP and CVP diversions may reduce movement out of less productive habitat in the central Delta compared to habitat closer to Suisun Bay. Fish screens and improved salvage operations implemented under the CVPIA, however, would reduce diversion-related losses of juvenile bass. In addition, habitat and food availability may be reduced compared to the No-Action Alternative by the upstream shift in estuarine salinity caused by reduced Delta outflow from July through November. CVPIA actions that alleviate the adverse effects of reduced Delta outflow on habitat and food availability include habitat restoration actions in the Delta, reduced pollutant levels, and the benefits during other months already identified.

Delta Smelt

Compared to the No-Action Alternative, beneficial impacts would accrue during all life stages of delta smelt. These benefits would be in response to reduced pollutant levels, reduced diversion, improved flow conditions affecting movement during March through June, and increased habitat and food web support in the Delta (Figure III-21). Delta smelt eggs would benefit from reduced pollutant levels, while larval, juvenile, and adult smelt would benefit from reduced pollutant levels, reduced diversion and habitat restoration actions in the Delta. Overall, delta smelt would benefit from Alternative 1 (Figure III-22).

Juvenile and adult delta smelt would benefit from fish screen improvements that would reduce entrainment losses. In addition, reduced Delta diversions from April through August would reduce loss of larval, juvenile, and adult delta smelt. Flow conditions supporting movement toward Suisun Bay would improve compared to the No-Action Alternative, primarily in response to a higher QWEST from May through August. An upstream shift in estuarine salinity during July and August, however, would moderate the potential benefit of a higher QWEST. Restoration

of shallow water and riparian habitats in the Delta would also benefit adult and juvenile delta smelt by increasing spawning and rearing habitat availability and food web support.

Although delta smelt would benefit from actions implemented under Alternative 1, not all actions would result in beneficial responses. CVP diversions from October through December would generally increase, thereby increasing juvenile and adult delta smelt mortality resulting from entrainment, impingement, and reduced flow out of the central Delta. Less flow toward Suisun Bay and increased flow toward the SWP and CVP diversions would reduce movement out of less productive habitat in the central Delta compared to habitat nearer Suisun Bay. Fish screens and improved salvage operations implemented under the CVPIA, however, would reduce the loss of affected fish.

In addition, habitat and food availability would be reduced compared to the No-Action Alternative by the upstream shift in estuarine salinity caused by reduced Delta outflow during October and November of some years. CVPIA actions that alleviate these adverse effects include habitat restoration actions in the Delta, reduced pollutant levels, and the benefits during other months already identified.

Longfin Smelt

Longfin smelt would benefit (Figure III-22) from CVPIA actions implemented in the Delta under Alternative 1. Beneficial impacts would accrue during all life stages in response to reduced pollutant levels, reduced entrainment losses, improved conditions affecting movement, increases in habitat, and improved food web support (Figure III-21). Increased outflow from January through March and reduced diversions from April through July may increase the movement of larvae and juveniles toward Suisun Bay (i.e., reduced attraction to the central and south Delta) and reduce diversion mortality. Restoration of shallow water habitat and downstream shift in estuarine salinity in January through March would increase spawning habitat availability and food web support. Fish screens and improved salvage operations implemented under the CVPIA would reduce loss of adult and juvenile fish.

Sacramento Splittail

Sacramento splittail would benefit (Figure III-22) from riverine and Delta actions implemented under Alternative 1. The primary benefit would accrue during the egg, larval, and juvenile rearing life stages in response to reduced pollutant levels, reduced diversion, increases in the quantity and quality of habitat, and increased food web support (Figure III-21). Adult and juvenile splittail would benefit from reduced diversions in the San Joaquin River and the Delta during March through July; as well as reduced diversion loss attributable to fish screen improvements. Habitat restoration would increase spawning and rearing habitat availability. Restoration of the meander belt on the Sacramento River may increase the availability of seasonally inundated habitat, important to splittail spawning success and potentially providing additional food web support. Shallow water habitat restoration in the Delta and downstream shift in estuarine salinity in January through March would increase spawning and rearing habitat availability and increase food web support.

Although Sacramento splittail would benefit from actions implemented under Alternative 1, habitat and food availability may be reduced compared to the No-Action Alternative by the upstream shift in estuarine salinity caused by reduced Delta outflow from July through November. CVPIA actions that may alleviate adverse effects of reduced Delta outflow on habitat and food availability include shallow water and riparian habitat restoration actions in the Delta and reduced pollutant levels. CVP diversions from December and January would generally increase and may increase diversion-related losses of adult splittail. Fish screens and improved salvage operations implemented under the CVPIA, however, would reduce the loss of affected fish.

Reservoir Species

Overall, changes in reservoir operations under Alternative 1 would have minimal effects on reservoir species. Under the No-Action Alternative and Alternative 1, monthly and annual variability in surface elevation is substantial, reflecting a response to meteorology and operations for water storage and flood control needs. The CVPIA actions implemented under Alternative 1 would increase simulated average monthly surface elevations and may benefit largemouth and spotted bass in Lake Oroville, Folsom Lake, and San Luis Reservoir compared to the No-Action Alternative. However, Alternative 1 would lower average monthly surface elevations and may adversely affect reservoir species in Shasta Lake, New Melones Reservoir, and Lake McClure. Change in simulated reservoir surface elevation affects suitable habitat availability and food web support. In Whiskeytown Lake, Camanche Reservoir, New Hogan Lake, New Don Pedro Reservoir, and Millerton Lake, conditions under Alternative 1 operations are similar to conditions under the No-Action Alternative and, therefore, reservoir habitat conditions would not be affected.

During the primary spawning and rearing period for spotted and largemouth bass in Folsom Lake, the volume of drawdown is less and surface elevation is higher compared to the No-Action Alternative. Slightly higher reservoir surface elevations may occur in Lake Oroville during the spring and early summer, increasing habitat and food availability. San Luis Reservoir had higher simulated surface elevation during spring and summer and reduced drawdown during April and May, increasing habitat and food availability, reducing predation, and reducing nest dewatering. Compared to the No-Action Alternative, increased drawdown was simulated for July in San Luis Reservoir; however, the increase is small compared to the magnitude of drawdown (greater than 30 feet) under both Alternative 1 and the No-Action Alternative.

Simulated operations for Shasta Lake, New Melones Reservoir, and Lake McClure indicate lower reservoir surface elevations and greater drawdown that may slightly reduce habitat and food availability compared to the No-Action Alternative.

RESPONSE BY ENVIRONMENTAL CONDITION

The following sections describe the changes expected in each environmental condition in response to CVPIA actions included in Alternative 1.

Water Temperature

Loss of individual chinook salmon and steelhead trout occurs when water temperature exceeds metabolic tolerances and causes mortality. Factors affecting water temperature that may be implemented under Alternative 1, but were not simulated for all rivers and streams, include reservoir operations; multilevel release shutter installation and modification; riparian, meander belt, and watershed restoration; and controlling and relocating agricultural return flow. In general, temperature conditions would improve (Figure III-21), benefiting all chinook salmon runs and steelhead trout that occur in the affected rivers and streams (see Attachment A, Monthly Species Occurrence in Each Watershed Compartment by Life Stage). For the Yuba River, reservoir operations and multilevel release shutter reoperation could improve temperature conditions for fall-run chinook salmon and for steelhead trout. Restoration of riparian vegetation and the meander belt could shade and cool smaller streams and increase cool microhabitat availability compared to the open channel habitat of larger rivers. Riparian and meander belt restoration actions are identified for the Sacramento River, minor tributaries, Yuba River, American River, Mokelumne River, and the Delta. The development of watershed restoration plans and plans to control or relocate agricultural return flows would potentially reduce warm-water inflow to the Sacramento and San Joaquin rivers and some tributary streams.

The assessment of water temperature uses simulated water temperature for Clear Creek and the Sacramento, Feather, American, and Stanislaus rivers. In addition, potential effects of simulated reservoir operations and flow are evaluated. The results of water temperature, flow, and reservoir simulation are described in the following sections. Reservoir operations under Alternative 1 generally correspond to water availability and flow and temperature needs identified in the restoration actions (see Alternatives Description Technical Appendix). Under Alternative 1, temperature conditions would improve on Clear Creek, the minor tributaries to the Sacramento River, and the Yuba River. However, on the American and Merced rivers, temperature conditions would decline (Figure III-21) during critical months.

Sacramento River and Tributaries. Simulations suggest that all life stages of fall-, late fall-, winter-, and spring-run chinook salmon and steelhead trout would be minimally affected by change in water temperature in the Sacramento River under Alternative 1 (Figure III-21).

In Clear Creek, water temperature would generally be lower compared to the No-Action Alternative (Figure III-21) and benefit fall-, late fall-, and spring-run chinook salmon and steelhead trout. During September and October, simulated water temperature increased into a range that could increase losses of spring- and fall-run chinook salmon eggs. In September, however, a temperature target of less than 60 degrees Fahrenheit for Clear Creek was met and reoperation of Whiskeytown Lake could address potential temperature-related impacts.

Under Alternative 1, Feather River temperatures would be minimally affected compared to the No-Action Alternative.

On the American River, simulated water temperature under Alternative 1 increases during critically important months for fall-run chinook salmon and steelhead trout (Figure III-21). The result of adverse water temperatures are reduced survival and reproductive success. Simulated water temperature increases during October (in wetter and cooler years) and November compared

to the No-Action Alternative, indicating potential adverse impacts on fall-run chinook salmon spawning. During most years, including drier and warmer years, water temperature during October is reduced compared to the No-Action Alternative, indicating a potential benefit to spawning fall-run chinook salmon. Elevated water temperature during June through September would adversely affect steelhead trout (Figure III-22). Restoration actions for reoperating or reconfiguring the multilevel release shutters could improve water temperature compared to conditions indicated by the simulation.

San Joaquin River and Tributaries. For the Stanislaus River, temperature simulation indicates improved water temperature compared to the No-Action Alternative (Figure III-21). Reduced water temperatures during April and May would benefit juvenile fall-run chinook salmon. Simulated water temperatures for October and November indicate adverse effects on fall-run spawning and incubation. The temperature changes in October and November are relatively small and actual water temperatures would be manipulated to meet an October 15 target of 56 degrees Fahrenheit.

Temperature simulations for the Mokelumne, Calaveras, Tuolumne, and Merced rivers are unavailable; therefore, change in temperature is evaluated through consideration of monthly reservoir surface elevations from August through October and average monthly river flow from May through October. Under Alternative 1, reduced flow in the Merced River during April and May would increase water temperature and adversely affect fall-run chinook salmon (Figure III-21) through increased loss of rearing juveniles. In October, reduced simulated flow and lower reservoir storage (drier years) may also increase water temperature and adversely affect spawning success of fall-run chinook salmon compared to conditions under the No-Action Alternative.

Flow and reservoir levels are similar to the No-Action Alternative for the Mokelumne and the Calaveras rivers, and temperature conditions for fall-run chinook salmon would not change under Alternative 1 (Figure III-21). Change in flow and reservoir surface elevation for the Tuolumne River would also be similar under Alternative 1 and the No-Action Alternative.

Diversion

Diversions cause mortality through entrainment, impingement on fish screens, abrasion, stress from handling, and increased predation. In the Sacramento and San Joaquin River basins, diversion is a concern for all fish species included in the impact assessment (Table III-9). Actions implemented under Alternative 1 that may reduce diversion loss include construction and improvement of fish screens, change in facility design to discourage predation, reduced diversion volume, and maintenance of estuarine salinity downstream of the Delta. Alternative 1 actions affecting diversions contribute to reduced overall fish loss on all watersheds (Figure III-21).

Fish screens would benefit juvenile and adult life stages of the representative species, but would provide minimal or no benefit to planktonic egg and larval life stages. Under Alternative 1, fish screen construction and improvement actions would be implemented for diversions on the Sacramento, Feather, Yuba, Bear, American, Mokelumne, Calaveras, Stanislaus, Tuolumne, and San Joaquin rivers and the Sacramento-San Joaquin Delta Estuary (Table III-2). In addition, actions to construct and improve fish screens would be implemented on minor tributaries to the Sacramento River, including Cow, Butte, Big Chico, and Battle creeks, and would benefit fall-

and spring-run chinook salmon and steelhead trout. Actions to reduce predation could be implemented for Woodbridge Dam on the Mokelumne River, benefitting primarily fall-run chinook salmon.

Under Alternative 1, fish screen construction and improvement would be the primary action contributing to reduced entrainment and impingement in the Sacramento and San Joaquin River basins. In rivers and streams, the volume diverted is similar for Alternative 1 and the No-Action Alternative. The timing and magnitude of diversions in the Delta, however, would change. Location of estuarine salinity, a factor influencing diversion mortality, would also change under Alternative 1.

Sacramento and San Joaquin Rivers and Tributaries. As previously stated, additional and improved fish screens would reduce losses of juvenile chinook salmon, steelhead trout, sturgeon, and American shad to diversions. Change in diversion volume would have minimal effects for most rivers. On the Sacramento River below Red Bluff, simulated diversions increase during September and October and potentially affect late fall- and winter-run chinook salmon. Installation of effective fish screens, however, would reduce mortality compared to the No-Action Alternative.

Sacramento-San Joaquin Delta Estuary. Compared to the No-Action Alternative, diversion from the Delta (primarily through the CVP and SWP pumping facilities) would decrease from April through September and increase during October through February. From April through September, decreased diversion compared to the No-Action Alternative would reduce entrainment and impingement of striped bass eggs, larvae and juveniles; delta smelt adult, larvae, and juveniles; longfin smelt adult larvae and juveniles; American shad eggs, larvae, and juveniles; juvenile steelhead trout; juvenile chinook salmon from all runs; juvenile sturgeon; and juvenile and adult Sacramento splittail. During October through February, increased Delta diversion would increase losses of juvenile striped bass; juvenile and adult delta smelt; adult longfin smelt; juvenile American shad; juvenile steelhead trout; and juvenile late fall-, winter-, and spring-run chinook salmon.

Diversion from April through September would affect fish that would benefit from fish screen improvements discussed above and egg and larval life stages that would not benefit. Reduced diversion would benefit all life stages. Compared to the No-Action Alternative, flow conditions in the Delta would partially determine diversion mortality and the potential benefit of reduced diversion (see Movement). During June, flow conditions would favor movement from the Sacramento River to the central and south Delta and could increase exposure of juvenile fall-run chinook salmon and striped bass eggs and larvae to diversion. Flow conditions affecting movement toward Suisun Bay (i.e., QWEST) may reduce the presence of juvenile chinook salmon (June only) and juvenile and larval striped bass and delta smelt in the central and south Delta during June, July, and August, further reducing diversion mortality.

Compared to the No-Action Alternative, increased diversion from October through February would primarily affect screenable-sized fish that would benefit from new fish screens and fish screen improvements implemented under Alternative 1. Diversion mortality, however, would increase for most representative species. American shad, steelhead trout, and chinook salmon enter the Delta as juveniles from the Sacramento River from October through February, and

exposure to increased diversion is related to transport from the Sacramento River through the DCC and Georgiana Slough (see Movement). Relative to the No-Action Alternative, flow conditions during November through February would not affect the movement of fish through the DCC and Georgiana Slough to the central and south Delta and, therefore, would not affect diversion losses. During October, however, flow conditions would reduce transport to the central and south Delta and fewer juveniles would be exposed to increased diversion.

Another factor increasing exposure to increased diversion from October through February is flow out of the central Delta (see Movement). Increased flow toward the CVP and SWP pumps from October through February may increase the vulnerability of juvenile striped bass; juvenile and adult delta smelt; adult longfin smelt; juvenile American shad; juvenile steelhead trout; and juvenile late fall-, winter-, and spring-run chinook salmon in the central and south Delta.

Change in Water Surface Level

Change in water surface level is assessed for rivers and reservoirs. In rivers, short-term (e.g., hourly, daily) change in water surface level causes mortality. For the impact assessment, CVPIA actions that address flow fluctuation are assumed to improve the survival of eggs and juveniles. In reservoirs, simulated drawdown is assessed to determine loss of reservoir species due to change in water surface level.

Rivers. Change in water surface level would affect losses of egg, larval, and juvenile life stages of chinook salmon, steelhead trout, and Sacramento splittail. Effects of CVPIA actions on conditions affecting the response of splittail to change in water surface level, however, cannot be determined with available information.

Under Alternative 1, CVPIA actions that reduce changes in water surface level would reduce mortality during spawning-incubation, rearing, and adult life stages for steelhead trout and chinook salmon compared to mortality under the No-Action Alternative. The CVPIA actions identify the need to address losses attributable to change in water surface elevation in the Sacramento, Yuba, American, Tuolumne, and Merced rivers (Figure III-21). More general flow-related actions would reduce changes in water surface level and thereby reduce losses of chinook salmon and steelhead trout in other Sacramento-San Joaquin basin rivers (Table III-4). In particular, Clear Creek flows are greatly increased (more than doubled overall), potentially improving flow stability.

Reservoirs. In Whiskeytown Lake, Camanche Reservoir, New Hogan Lake, New Don Pedro Reservoir, Lake McClure, and Millerton Lake, drawdown under Alternative 1 is similar to drawdown under the No-Action Alternative. Consequently, no change in the effects from drawdown are expected under Alternative 1.

Under Alternative 1 operations, the volume of drawdown in Folsom Lake is less during April through September. The spawning and incubation life stages would benefit from reduced redd desiccation. Drawdown also forces rearing individuals to move, exposing them to predation. Hence, reduced drawdown would benefit rearing juveniles by reducing predation.

Under Alternative 1, simulated drawdown of Shasta Lake increases in October, November, January to March, and August compared to the No-Action Alternative. Consequently, increased drawdown would increase predation on rearing juveniles and adults. Drawdown of New Melones Reservoir increases during May and June and would adversely affect spawning, incubation, and rearing through increased predation and redd dewatering.

Under Alternative 1, San Luis Reservoir undergoes reduced drawdown during December through February, April, and August. Rearing juveniles would benefit when drawdown is reduced. Improved spawning and incubation conditions would result from reduced redd dewatering in April. Drawdown increases in July; however, the change in drawdown is small compared to the magnitude of simulated monthly drawdown under both the No-Action Alternative and Alternative 1 (i.e., greater than 30 feet).

Pollutants

The factors considered in the assessment of pollutants are flow and water quality. Hence, pollutant concentrations would decrease in the Bay-Delta and the Sacramento, Mokelumne, San Joaquin, Tuolumne, and Merced rivers (Figure III-21). The relationship between flow change attributable to CVPIA actions and pollutant inputs cannot be determined with available data. Site-specific documents should be required to address specific pollutant concentrations affected by flow.

Reduced pesticide application (e.g., by reducing agricultural acreage) and actions to develop watershed management plans and stream watch programs would reduce input of pollutants to rivers and streams and improve conditions for all species and all life stages (Table III-3). Additional actions on the Sacramento River address pollutant problems associated with metal sludge in Keswick Reservoir and discharge from the ACID canal. Stream watch programs should have beneficial impacts on the Mokelumne, Tuolumne, and Merced rivers. The Sacramento and San Joaquin rivers and tributaries drain to the Delta and all representative species in the Delta would benefit from actions to reduce pollutant inputs to the rivers.

Levels of pollutants could be reduced by the restoration of meander belts, riparian habitat, and shallow water habitat on rivers, streams, and in the Delta, by enhancing environmental processes that remove pollutants from the food web (Table III-3). Actions addressing erosion control in watersheds and gravel mining would also reduce pollutant input.

Predation

Predation could increase through changes in ecosystem structure that increase prey vulnerability or increase predator feeding efficiency. Predation is addressed through CVPIA actions that reduce predation at diversion facilities and dams (see Diversion and Movement). Other CVPIA actions include modification of physical habitat to isolate ponds from the main channels of the Stanislaus, Tuolumne and Merced rivers (Figure III-21). The ponds support warm-water species that prey on juvenile fall-run chinook salmon. Under Alternative 1, actions to isolate ponds from the main river flow would reduce predator habitat and reduce loss of juvenile fall-run chinook salmon.

Movement

Movement refers to the active and passive movement of organisms. Movement is affected by flow (including velocity, turbulence, and direction), diversion, barriers, water quality, and physical habitat conditions. Some early life stages are incapable of controlling their position and are solely dependent on hydrologic conditions for their movement. Others are capable of controlling their position but respond according to perceived conditions that are under the influence of the CVP (i.e., an organism may move into unproductive habitat in response to flow conditions).

Sacramento and San Joaquin Rivers and Tributaries. Barriers and river flow affect juvenile and adult chinook salmon and steelhead trout migration. River flow over barriers and predation associated with barriers increase mortality during downstream migration of juvenile chinook salmon and steelhead trout. Increased river flow and barrier removal or modification would improve conditions affecting movement and reduce mortality. During upstream migration, inappropriate flows can attract adult salmon and steelhead into unproductive habitat where survival and reproductive success are low, negatively affecting movement. During downstream migration, river flow is assumed to provide cues that support migration of juvenile chinook salmon and steelhead trout toward marine habitat essential for completing their life cycle.

Flow actions that provide pulse flows would benefit juvenile chinook salmon through increased migration success. Increased flows during April through June in Alternative 1 would potentially provide pulse flows on Clear Creek and the American and Stanislaus rivers. Pulse flows are expected to primarily benefit juvenile fall-run chinook salmon migration, although these flows would contribute to improved habitat quality and quantity for other life stages and species. Overall, increased flows in Alternative 1 would provide improved habitat quality and quantity on Clear Creek and the American and Stanislaus rivers (Figure III-21).

The analysis for the PEIS assumes that structural actions to construct barriers that block migration of adult chinook salmon and steelhead trout into unproductive habitat would reduce prespawning mortality of these fish. Alternative 1 would implement the construction of barriers at Crowley Gulch on Cottonwood Creek, Grover Diversion Dam and Coleman Powerhouse on Battle Creek, and on the mainstem of the San Joaquin River upstream of the confluence of the Merced River. These barriers would contribute to improved movement (Figure III-21) of adult fall-run chinook salmon into more productive spawning and rearing habitat. Construction of barriers on Battle Creek would also benefit spring-run chinook salmon and steelhead trout.

Structural actions could include the construction or removal of barriers that restrict the movement of representative species. Alternative 1 also includes removal of barriers on minor tributaries such as Mill and Butte creeks, and modification of the spill structure on Daguerre Point Dam on the Yuba River. Structural actions that remove barriers to movement would contribute to increased habitat quality and quantity (Figure III-21) on these same streams. These structural actions would benefit chinook salmon and steelhead trout (Figure III-22) on the streams listed. Juvenile life stages of these species (fall- and spring-run chinook salmon and juvenile steelhead trout) would benefit the greatest through increased survival conditions. Increased flow on Clear Creek would increase habitat quality and quantity conditions which support the downstream migration of juvenile chinook salmon and steelhead trout.

Reduced Sacramento River flow occurs under Alternative 1 as a result of less water exported from the Trinity River basin to the Sacramento River. Reduced river flow would increase mortality during downstream transport of planktonic eggs and larvae of striped bass and American shad.

Striped bass spawn in the Sacramento River during late April, May, and June. In Alternative 1, Sacramento River flow during April through June is reduced which would reduce the movement (Figure III-21) of eggs and larvae, and contribute to increased mortality of these life stages compared to the No-Action Alternative. The effect of reduced flow in the Sacramento River would be an adverse impact to both striped bass and American shad (Figure III-22).

American shad spawn in the Sacramento River during May through July. American shad are similar to striped bass and would be exposed to a similar increase in mortality of eggs and larvae. Simulated American River flow in Alternative 1 is lower during June and July compared to the No-Action Alternative. Reduced flow conditions during these months would increase mortality of eggs spawned in the American River and adversely affect American shad productivity. Feather and Yuba river flow is similar for Alternative 1 and the No-Action Alternative.

Sacramento-San Joaquin Delta Estuary. Avoiding movement into the central and south Delta or enhancing movement toward Suisun Bay benefits Delta organisms. Net channel flow toward Suisun Bay is assumed to provide conditions that increase the movement of organisms out of unproductive habitat in the central and south Delta. In addition, reduced DCC and Georgiana Slough volume would reduce the proportion of organisms carried into the central Delta, thereby reducing losses potentially incurred in central and south Delta habitats.

Outmigrating juvenile chinook salmon and steelhead trout and egg and larval striped bass are assumed to enter the DCC and Georgiana Slough in proportion to the net flow division from the Sacramento River. Sacramento River flow passing through the DCC and Georgiana Slough carries organisms into the central Delta. Compared to organisms that continue down the Sacramento River, these organisms are exposed to increased mortality as a result of adverse conditions such as increased diversions, increased water temperatures, and increased predation. Under Alternative 1, the proportion of Sacramento River flow entering the DCC and Georgiana Slough is similar to the proportion under the No-Action Alternative except during October, June, and July. During October, the proportion of flow entering the DCC and Georgiana Slough is less than under the No-Action Alternative. This would benefit juvenile late fall- and spring-run chinook salmon that emigrate during October, although the benefit would be minimal because of the marginal presence during October. During June, emigrating fall- and late fall-run chinook salmon would be exposed to greater risk to mortality as a result of the increased proportion of flow entering the DCC and Georgiana Slough. Mortality of these juveniles would be lessened as a result of increased flow out of the central Delta and reduced diversion (see Diversion).

During June and possibly early July, increases in the proportion of Sacramento River flow entering the DCC and Georgiana Slough would increase the proportion of striped bass eggs and larvae in the central Delta. Similar to juvenile chinook salmon, the adverse effects of movement toward the central Delta would be lessened by the combination of reduced diversion (see Diversion) and increased flow toward Suisun Bay.

Under Alternative 1, an increased flow out of the central Delta is indicated by an increased QWEST as compared to the No-Action Alternative. Increased flow out of the central Delta would increase the movement in the Delta (Figure III-22) of larval and juvenile chinook salmon and steelhead trout and juvenile striped bass and delta smelt. Habitat quality and quantity would increase for these same species as they have increased movement from the central and south Delta, areas of less productive habitat, toward Suisun Bay, an area of greater productive habitat. Increased movement would occur during May, June, July, and August. However, an upstream shift in estuarine salinity distribution in response to reduced Delta outflow during July, August, and September would reduce habitat availability and moderate the movement of striped bass and delta smelt to downstream habitat (see Quantity and Quality of Habitat and Diversion).

Compared to the No-Action Alternative, flow conditions during October through February may increase loss of juvenile striped bass, delta smelt, American shad, steelhead trout, and late fall-, winter-, and spring-run chinook salmon in the central and south Delta. Adverse conditions affecting movement through the central and south Delta may be attributable to reduced QWEST, reduced Delta outflow (October and November), and increased diversion (see Diversion).

Quantity and Quality of Habitat

In the Sacramento and San Joaquin River basins, loss of habitat has been a factor in the decline of many species and suitable habitat availability is critical to the maintenance and increase of current populations. CVPIA actions under Alternative 1 to reduce the rate of degradation of existing habitats, restore meander belts, restore riparian vegetation, restore spawning gravel, create side channels, limit bank protection, and prevent illegal stream alteration. CVPIA actions to restore habitat would benefit the representative species in rivers and the Delta. Therefore, except for the Merced River, habitat quantity and quality would increase for all watersheds under Alternative 1 (Figure III-21).

Sacramento River and Tributaries. Habitat availability in the Sacramento River and its tributaries would increase for a variety of reasons under Alternative 1. Restoration of spawning gravel would increase spawning habitat for chinook salmon and steelhead trout, potentially reducing mortality caused by nest superimposition. Restoration of the meander belt from Keswick Reservoir to Chico would increase habitat complexity and restore natural river processes (e.g., erosion, seasonal flooding). The meander belt would increase rearing habitat for juvenile chinook salmon (all runs), steelhead trout, American shad, and sturgeon. Meander belt restoration may also provide additional spawning and rearing habitat for Sacramento splittail.

Habitat availability for fall-run and spring-run chinook salmon and steelhead trout fry and juvenile rearing in the tributaries to the Sacramento River would also be improved under Alternative 1. Channel habitat restoration on Antelope Creek, spawning gravel enhancement on Mill, Deer, and Big Chico creeks, and pool cleaning procedures on Big Chico Creek are actions identified under Alternative 1 that would increase or improve habitat. Channel habitat and spawning gravel will be restored and enhanced and erosion control measures initiated for Clear Creek and the adjacent watershed. On the Feather River, enhancement of spawning gravel would benefit spring- and fall-run chinook salmon. Fall-run chinook salmon and steelhead trout would benefit from actions implemented on the Yuba River, including purchase of land for conservation easements, channel and riparian restoration, and the creation of secondary channels to provide spawning and rearing

habitats. Actions included in Alternative 1 for the American River terminate the program to remove woody debris and implement channel and riparian restoration, including the creation of side channels. Spawning and rearing life stages of chinook salmon and steelhead trout would benefit.

CVPIA actions that remove physical barriers or improve movement over barriers improve access to upstream habitat and increase habitat availability. Under Alternative 1, structural actions to improve passage to upstream habitat would be implemented on Clear Creek and minor tributaries to the Sacramento River, as well as on the Feather, Yuba, Mokelumne, and Calaveras rivers (Table III-2 and Figure III-20). Most access improvement actions target chinook salmon and steelhead trout; although sturgeon, American shad, and Sacramento splittail could also benefit.

A fish ladder would be constructed at McCormick-Saeltzer Dam in Clear Creek, benefitting fall- and spring-run chinook salmon and steelhead trout. On Battle Creek, passage at Coleman National Fish Hatchery and Eagle Canyon would be modified and improved. Dams on Mill and Butte creeks would be removed; a fish ladder and fishway would be installed at Iron Canyon and Lindo Channel on Big Chico Creek; fish ladders also would be installed on Butte Creek. These actions would benefit fall- and spring-run chinook salmon and steelhead trout.

Improved passage for sturgeon was identified under the restoration actions for the Feather River. Under Alternative 1, passage for fall-run chinook salmon and steelhead trout would be improved at Daguerre Point Dam on the Yuba River. Modification of passage around diversion dams is also identified for the Calaveras River, potentially benefitting fall- and winter-run chinook salmon.

For the purposes of the PEIS, increased flow is assumed to increase habitat availability for chinook salmon, steelhead trout, striped bass, American shad, green sturgeon and white sturgeon, and Sacramento splittail. Site-specific documents (e.g., ongoing instream flow studies on the American and Sacramento rivers) will be required, however, to determine specific flow needs and to address the specific beneficial and adverse impacts of meeting those needs.

In the Sacramento River, increased flow from October through April (primarily an increase in low flows) would increase habitat availability. Increased spawning habitat would be available for fall-, late fall-, and spring-run chinook salmon and steelhead trout and potentially for Sacramento splittail and sturgeon. Increased flow may provide increased rearing habitat for all runs of chinook salmon, steelhead trout, sturgeon, and splittail. During May through September, reduced flow and warmer water temperature compared to the No-Action Alternative would reduce habitat availability for fall-, late fall-, winter-, and spring-run chinook salmon and for steelhead. Warmer water temperature may reduce the downstream extent of habitat suitable for juvenile late fall- and spring-run chinook salmon and for steelhead trout, particularly in reaches downstream of RBDD. Most fall-run chinook salmon outmigrate before mid-June and would not be as affected by change in rearing habitat.

Habitat availability in Clear Creek would greatly improve under Alternative 1 in response to increased flow, especially concerning fry and juvenile rearing for fall- and spring-run chinook salmon and steelhead trout. Flow increases for all simulated months compared to the No-Action Alternative, increasing the availability of habitat.

Improving flow conditions has been identified as an objective for increasing habitat for fall- and spring-run chinook salmon in the Feather and Yuba rivers. Simulated flow data, however, show little difference between Alternative 1 and the No-Action alternative for either river.

In the American River, increased flow from October through March may provide additional spawning and rearing habitat for fall-run chinook salmon and steelhead trout. Reduced flow during June through September would reduce rearing habitat availability, primarily affecting steelhead trout.

San Joaquin River and Tributaries. Habitat availability would increase in the San Joaquin River and its tributaries. Restoration actions on the Merced, Tuolumne, Stanislaus, Mokelumne, and mainstem San Joaquin rivers may include watershed improvements, restoration and protection of instream and riparian habitat, potential restoration of spawning gravels, prevention of illegal stream alterations, and limits on future bank protection activities. The actions would benefit spawning and rearing life stages of fall-run chinook salmon, American shad, sturgeon, and Sacramento splittail.

Flow under Alternative 1 is similar to flow under the No-Action Alternative for the Tuolumne River. On the Stanislaus River, increased flow from February through June would improve and increase rearing habitat, benefitting juvenile fall-run chinook salmon and possibly American shad. Increased flow in October may increase spawning habitat and benefit fall-run chinook salmon. In the Merced River, reduced flow during April and May would reduce habitat availability and increase water temperature, potentially reducing the downstream extent of habitat suitable for juvenile fall-run chinook salmon rearing. During October, lower flow under Alternative 1 may reduce spawning habitat and adversely affect fall-run chinook salmon. Hence, habitat availability for spawning and rearing would be reduced (Figure III-21), potentially affecting fall-run chinook salmon using the Merced River (Figure III-22).

Sacramento-San Joaquin Delta Estuary. Delta and estuarine habitat is critical to all of the representative species. CVPIA actions to restore habitat include actions that may restrict dredging, restore riparian vegetation, limit bank protection, and restore tidal shallow water habitat. Restoration of shallow water habitat would increase rearing habitat availability for all species and spawning habitat availability for delta smelt, longfin smelt, and Sacramento splittail.

Delta outflow may affect the quantity and quality of habitat through effects on estuarine salinity. Increased outflow and location of X2 downstream of the Delta and in Suisun Bay increase habitat availability for Sacramento splittail, delta smelt, longfin smelt, and striped bass. Compared to the No-Action Alternative, X2 would shift farther downstream during January, February, and March of low outflow years and would increase spawning and early rearing habitat availability and quality for Sacramento splittail, delta smelt, and longfin smelt. From July through September, Delta outflow would be less than outflow simulated for the No-Action Alternative and X2 would shift upstream. Upstream shift in X2 would reduce habitat availability and quality for striped bass and delta smelt. Habitat quality is related to shallow water habitat availability, potential increase in exposure to diversion (see Diversion), and reduced food web support (see Food Web Support).

Reservoirs. Reservoir water surface area plays an important role in defining reservoir fish productivity. Higher reservoir surface elevation (representing greater surface area) typically

provides greater spawning opportunities, cover, and habitat diversity and results in more diverse and larger fish populations. Restoration actions are not specifically identified for reservoirs in the CVPIA or the restoration actions.

In Lake Oroville, from February through July, reservoir surface elevation would be higher under Alternative 1, increasing habitat availability for all life stages of both largemouth and spotted bass. Compared to the No-Action Alternative, Folsom Lake would have higher surface elevations from July to November compared to the No-Action Alternative, which would provide additional habitat for all life stages of the two bass species, especially juvenile and adult rearing. Beneficial impacts related to spawning and incubation would occur in July. Folsom Lake surface elevations would be lower under Alternative 1 during January through May. The lower levels in April and May would reduce habitat availability for spawning and rearing life stages. Lower reservoir surface elevations during January through March would have minimal effects on habitat for reservoir species.

In Shasta Lake, New Melones Reservoir, and Lake McClure, year-round lower surface elevations under Alternative 1 operations would reduce habitat availability for all life stages of largemouth and spotted bass. Alternative 1 operations would increase the surface elevation in San Luis Reservoir during January through August. Higher surface elevations would provide additional habitat for spawning and rearing.

Food Web Support

Food web support includes nutrient availability, production of food, and availability of food. Organisms that provide the food base for fish species are affected by the same environmental conditions affecting the representative fish species. The response of fish species described for Alternative 1 in the preceding sections generally apply to food web organisms. Food web support would increase for all watersheds except for the Merced River under Alternative 1 (Figure III-21). In the Merced River, habitat for food web organisms would remain unchanged from the No-Action Alternative as a result of flow.

Sacramento and San Joaquin Rivers and Tributaries. Food web support would increase for the representative species in the Sacramento River. Restoration of the meander belt from Keswick Reservoir to Chico, riparian restoration, the creation of secondary channels, termination of the program to remove woody debris, watershed improvements, restoration and protection of instream habitat, and limits on future bank protection activities would increase food web support for the representative species under Alternative 1 (see Quantity and Quality of Habitat). The actions would increase nutrient, organic carbon, and food organism input to the aquatic ecosystem. In addition, reduced pollutant inputs would increase food organism survival and food web support for riverine species (see Pollutants).

Diversion under Alternative 1 would have minimal effects on food web support because the changes in diversion volumes from rivers compared to the No-Action Alternative would be small. Food web organisms are generally too small to benefit from new or improved fish screens.

Sacramento-San Joaquin Delta Estuary. Food web support would increase for the representative species in the Delta. CVPIA actions to restore habitat, including actions that may

restrict dredging, restore riparian vegetation, limit bank protection, and restore tidal shallow water habitat, would increase nutrient, organic carbon, and food organism input to the aquatic ecosystem and would increase food web support for the representative species. In addition, upstream restoration actions previously described would increase input of nutrient, organic carbon, and food organisms and increase food web support in the Delta.

Under Alternative 1, reduced pollutant inputs would increase food organism survival and food web support for Delta species (see Pollutants). The Sacramento and San Joaquin rivers and tributaries drain to the Delta and all food web organisms in the Delta would benefit from actions to reduce pollutant input to the rivers.

Diversion in the Delta under Alternative 1 would affect food web support. Compared to the No-Action Alternative, diversions from the Delta (primarily through the CVP and SWP pumping facilities) would decrease from April through September and increase during October through February. Decreased diversion would reduce the loss of food web organisms, nutrients, and organic carbon from April through September, a primary period of production in the Delta. Loss of food web organisms, nutrients, and organic carbon to diversions would increase during October through February. Food web organisms are generally too small to benefit from new or improved fish screens.

The movement of food web organisms may be affected by net channel flow in the Delta. As indicated by a higher QWEST, flow conditions under Alternative 1 may increase movement of food web organisms out of the central and south Delta and toward Suisun Bay during May, June, July, and August. Upstream shift in estuarine salinity distribution in response to reduced Delta outflow during July, August, and September, however, could moderate any benefit in movement out of the central and south Delta. Flow conditions from October through February may increase loss of food organisms by retaining them in the central Delta because QWEST and Delta outflow (October and November) are reduced.

In addition, the upstream shift in estuarine salinity may reduce food web support for species geographically associated with specific salinity because productivity is generally higher in the shallow shoal habitat of Suisun Bay than in the Delta. Compared to the No-Action Alternative, X2 would shift farther downstream during January, February, and March of low outflow years and would increase food web support for Sacramento splittail, delta smelt, and longfin smelt. From July through September, Delta outflow would be less than outflow simulated for the No-Action Alternative and X2 would shift upstream. Upstream shift in X2 would reduce food web support for striped bass, delta smelt, and other species. The upstream shift would also affect production of food organisms that require specific salinity conditions.

Reservoirs. The primary factor affecting food web support for reservoir species is surface area. Under Alternative 1, food web support would increase for reservoirs with greater surface elevation compared to the No-Action Alternative (see Quantity and Quality of Habitat). In addition, food web support would be adversely affected by drawdown (see Change in Water Surface Level).

SUPPLEMENTAL ANALYSIS 1a

Supplemental Analysis 1a would result in beneficial impacts on all representative fish species by improving environmental conditions and increasing habitat availability. Supplemental Analysis 1a is identical to Alternative 1 except that additional beneficial impacts are realized with the addition of Delta (b)(2) Water Management. Differences between Alternative 1 and Supplemental Analysis 1a are described compared to the No-Action Alternative, resulting primarily from change in Delta exports. All flow-related, structure-related, habitat-related, and species management actions implemented under Alternative 1 would also be implemented under Supplemental Analysis 1a. River flow and reservoir operations are also similar for Alternative 1 and Supplemental Analysis 1a.

RESPONSE BY REPRESENTATIVE SPECIES

Compared to the No-Action Alternative, actions under Supplemental Analysis 1a would benefit all of the representative species. Most of the beneficial impacts are the same as described in Alternative 1.

Chinook Salmon

Effects on chinook salmon are discussed separately for fall, late fall, winter, and spring runs. All runs would benefit under Supplemental Analysis 1a compared to the No-Action Alternative.

Fall-Run Chinook Salmon. Implementation of the CVPIA actions under Supplemental Analysis 1a would improve habitat conditions for fall-run chinook salmon compared to conditions under the No-Action Alternative.

For a description of the beneficial and adverse impacts of actions under Supplemental Analysis 1a that would affect riverine habitat, see Alternative 1.

Delta impacts are also similar to those of Alternative 1. However, a higher QWEST during April and May would reduce attraction to the central and south Delta for juvenile chinook salmon, including juvenile fall-run originating from the Sacramento, San Joaquin, and Mokelumne rivers. Reduced diversion during April and May would reduce diversion-related mortality.

Late Fall-Run Chinook Salmon. Implementation of the CVPIA actions under Supplemental Analysis 1a would improve habitat conditions for late fall-run chinook salmon compared to conditions under the No-Action Alternative. For a description of the beneficial and adverse impacts of actions implemented under Alternative 1a that would affect riverine and Delta habitats, see Alternative 1.

Entrainment and impingement would be further reduced by reduced Delta diversion during November, April, and May.

Winter-Run Chinook Salmon. Similar to late fall-run, winter-run chinook salmon would benefit under Supplemental Analysis 1a. For a description of the beneficial and adverse impacts of actions under Supplemental Analysis 1a that would affect riverine and Delta habitats, see Alternative 1.

In the Sacramento-San Joaquin Delta Estuary, juvenile winter-run would benefit from reduced diversion during December and April.

Spring-Run Chinook Salmon. Similar to the other runs, spring-run chinook salmon would also benefit Supplemental Analysis 1a. For a description of the beneficial and adverse impacts of actions under Supplemental Analysis 1a that would affect riverine and Delta habitats, see Alternative 1.

Losses to diversions would be reduced further by decreased Delta diversion during November, December, April, and May.

Steelhead Trout

Steelhead trout is a cool-water species with needs similar to the chinook salmon runs previously discussed. For a description of the beneficial and adverse impacts of actions under Supplemental Analysis 1a that would affect riverine and Delta habitats, see Alternative 1.

In the Sacramento-San Joaquin Delta Estuary, juvenile steelhead trout would benefit from further reductions in diversion during April and May.

Sturgeon

For a description of the beneficial and adverse impacts of actions under Supplemental Analysis 1a that would affect sturgeon, see Alternative 1.

American Shad

American shad would benefit from CVPIA actions under Supplemental Analysis 1a. For a description of the beneficial and adverse impacts of actions under Supplemental Analysis 1a that would affect riverine and Delta habitats, see Alternative 1.

Additional reductions in Delta diversions during November, December, April, and May would reduce losses of egg, larval, and juvenile shad occurring in Delta habitats.

Striped Bass

Many actions under Supplemental Analysis 1a would affect striped bass, similar to the impacts described for Alternative 1. In addition, reduced Delta diversions during April and May would further reduce losses of egg, larval, and juvenile striped bass. Additional improvements in conditions affecting movement, compared to the No-Action Alternative, would result primarily from increases in QWEST during April and May.

Delta Smelt

Beneficial and adverse impacts on delta smelt would be similar to those described for Alternative 1. In addition, reduced diversions and a higher QWEST during November, December, April, and May would reduce the loss of larval, juvenile, and adult delta smelt. Conditions

affecting movement would improve, primarily in response to increases in QWEST. Losses to diversion would also be further reduced in April and May.

Longfin Smelt

Beneficial and adverse impacts on longfin smelt would be similar to those described for Alternative 1.

Sacramento Splittail

Sacramento splittail would benefit from riverine and Delta actions implemented under Supplemental Analysis 1a. For a description of the beneficial and adverse impacts of actions under Alternative 1a that would affect riverine and Delta habitat, see Alternative 1. In addition, adult and juvenile splittail would benefit from further reductions in Delta diversions during April and May.

Reservoir Species

Beneficial and adverse impacts of actions under Supplemental Analysis 1a that would affect reservoir species are the same as those described for Alternative 1, except for San Luis Reservoir. Effects of actions included in Supplemental Analysis 1a are described here for San Luis Reservoir.

Overall, a change in San Luis Reservoir operation under Supplemental Analysis 1a would have minimal effects on reservoir species. Under the No-Action Alternative and Supplemental Analysis 1a, monthly and annual variability in surface elevation is substantial, reflecting a response to meteorology and operations for water storage and flood control needs. The CVPIA actions under Supplemental Analysis 1a would lower the water surface elevation in San Luis Reservoir compared to surface elevation under the No-Action Alternative. Lower reservoir surface elevations would reduce habitat available for spawning and rearing by largemouth and spotted bass and would reduce food web support.

Under Supplemental Analysis 1a, San Luis Reservoir undergoes reduced drawdown during December through March and during August. Rearing juveniles would benefit from reduced predation and increased food web support when drawdown is reduced. Loss of spawning-incubation and rearing life stages to drawdown would increase during April through July. Increased drawdown would have minimal effects in June and July because the change in drawdown is small compared to the magnitude of simulated monthly drawdown under both the No-Action Alternative and Supplemental Analysis 1a (i.e., greater than 30 feet).

RESPONSE BY ENVIRONMENTAL CONDITION

The following sections describe, for each environmental condition, the species responses to CVPIA actions included in Supplemental Analysis 1a.

Water Temperature

For a description of change in water temperature compared to the No-Action Alternative, see Alternative 1.

Diversion

For a description of the beneficial and adverse impacts of fish screen improvements and changes in river diversions, compared to the No-Action Alternative, see Alternative 1.

Compared to the No-Action Alternative, diversion from the Delta (primarily through the CVP and SWP pumping facilities) would decrease from April through September and increase during October, January, February, and March. During April through September, decreased diversion compared to the No-Action Alternative would reduce losses of striped bass eggs, larvae, and juveniles; delta smelt adult, larvae, and juveniles; longfin smelt adult, larvae, and juveniles; American shad eggs, larvae, and juveniles; juvenile steelhead trout; all runs of juvenile chinook salmon; juvenile sturgeon; and juvenile and adult splittail. Compared to Alternative 1, Supplemental Analysis 1a would result in further reductions in April and May diversions, leading to reductions in diversion-related losses. During October and from January through March, increased Delta diversion would increase losses of juvenile striped bass; juvenile and adult delta smelt; adult longfin smelt; juvenile American shad; juvenile steelhead trout; and juvenile late fall-, winter-, and spring-run chinook salmon. Under Supplemental Analysis 1a, reductions in November and December diversions compared to Alternative 1 during most simulated years would reduce losses of the same species.

Change in Water Surface Level

Change in water surface level is assessed for rivers and reservoirs. In rivers, the effects of actions under Supplemental Analysis 1a would be the same as described for Alternative 1. In reservoirs, the results of simulated drawdown are the same as described under Alternative 1, except for San Luis Reservoir.

Under Supplemental Analysis 1a, San Luis Reservoir undergoes reduced drawdown from December through March and during August. Rearing juveniles would benefit when drawdown is reduced. Loss of spawning-incubation and rearing life stages to drawdown would increase from April through July. Increased drawdown would have minimal effects in June and July because the change in drawdown is small compared to the magnitude of simulated monthly drawdown under both the No-Action Alternative and Supplemental Analysis 1a (i.e., greater than 30 feet).

Pollutants

For a description of change in pollutants compared to the No-Action Alternative, see Alternative 1.

Predation

For a description of change in predation compared to the No-Action Alternative, see Alternative 1.

Movement

Conditions affecting movement under Supplemental Analysis 1a are similar to conditions described for Alternative 1.

In addition, as indicated by a higher QWEST, flow conditions under Supplemental Analysis 1a may increase the movement of larval and juvenile striped bass and delta smelt and juvenile chinook salmon and steelhead trout out of the central and south Delta and toward Suisun Bay during April, May, June, July, and August compared to Alternative 1. Furthermore, flow conditions during November and December would reduce the loss of juvenile striped bass; delta smelt; American shad; steelhead trout; and late fall-, winter-, and spring-run chinook salmon in the central and south Delta. Improved flow conditions in central and south Delta habitats are attributable to a higher QWEST, increased Delta outflow, and reduced diversion (see Diversion).

Quantity and Quality of Habitat

In rivers, the effects of actions under Supplemental Analysis 1a would be the same as described for Alternative 1. In the Delta, the effects of habitat restoration actions are the same as described for Alternative 1, but flow effects differ. The effects of Delta flow conditions on quantity and quality of habitat under Supplemental Analysis 1a are described in this section. In reservoirs, simulated reservoir surface elevations are the same as described under Alternative 1, except for San Luis Reservoir. Effects of Supplemental Analysis 1a operations on reservoir species in San Luis Reservoir are described in the section Reservoirs.

Sacramento-San Joaquin Delta Estuary. Delta outflow may affect the quantity and quality of habitat through effects on estuarine salinity. Increased outflow and location of X2 downstream of the Delta and in Suisun Bay increase habitat availability for Sacramento splittail, delta smelt, longfin smelt, and striped bass. Compared to the No-Action Alternative, X2 would shift farther downstream during January, February, April, May, and June and would increase spawning and early rearing habitat availability and quality for Sacramento splittail, delta smelt, and longfin smelt. Compared to Alternative 1, additional outflow during April and May would place X2 further downstream and would provide additional habitat.

From July through September, Delta outflow would be less than outflow simulated for the No-Action Alternative and X2 would shift upstream. Upstream shift in X2 would reduce habitat availability and quality for striped bass and delta smelt. Habitat quality is related to shallow water

habitat availability, potential increase in diversion mortality (see Diversion), and reduced food web support (see Food Web Support).

Reservoirs. Supplemental Analysis 1a operations would lower the water surface elevation in San Luis Reservoir compared to surface elevation under the No-Action Alternative. Lower surface elevations would reduce habitat available for spawning and rearing by largemouth and spotted bass.

Food Web Support

The response of fish species under Supplemental Analysis 1a described in the preceding sections generally apply to food web organisms.

Sacramento and San Joaquin Rivers and Tributaries. For a description of change in food web support compared to the No-Action Alternative, see Alternative 1.

Sacramento-San Joaquin Delta Estuary. In the Delta, the effects of habitat restoration actions are the same as described for Alternative 1, but flow and diversion effects differ. Decreased diversion compared to Alternative 1 and the No-Action Alternative would reduce the loss of food web organisms, nutrients, and organic carbon during April and May, a primary period of production in the Delta. During most years, diversion during November and December would also be reduced under Supplemental Analysis 1a, and diversion losses from the Delta would decrease. As indicated by a higher QWEST, flow conditions under Supplemental Analysis 1a may increase movement of food web organisms out of the central and south Delta and toward Suisun Bay during April and May. Compared to the No-Action Alternative and Alternative 1, X2 would shift farther downstream during April and May and would increase food web support for Sacramento splittail, delta smelt, and longfin smelt.

Reservoirs. The primary factor affecting food web support for reservoir species is surface area. Under Supplemental Analysis 1a, food web support in reservoirs would be similar to those described for Alternative 1.

SUPPLEMENTAL ANALYSIS 1b

Supplemental Analysis 1b would result in beneficial impacts on all representative fish species by reducing loss of individual organisms, increasing habitat availability, and increasing life history diversity. Supplemental Analysis 1b is identical to Alternative 1 except that barriers are added for Georgiana Slough and Old River in the Delta. Under Supplemental Analysis 1b, a barrier on Georgiana Slough is assumed to operate in conjunction with the DCC. The barrier would be operated (e.g., periodically closed) from November from June to assist in the successful outmigration of chinook salmon and steelhead trout. A barrier on Old River would be closed in April and May, except during flood conditions, to assist the successful outmigration of fall-run chinook salmon from the San Joaquin River. Operations would also consider Delta channel conditions in the lower San Joaquin River and in the central Delta that benefit striped bass, delta smelt, longfin smelt, and other Delta species.

Differences between Alternative 1 and Supplemental Analysis 1b are described compared to the No-Action Alternative, resulting primarily from change in Delta flow patterns. All flow-related, structure-related, habitat-related, and species management actions implemented under Alternative 1 would also be implemented under Supplemental Analysis 1b. River flow and reservoir operations are the same as described for Alternative 1.

RESPONSE BY REPRESENTATIVE SPECIES

Compared to the No-Action Alternative, actions implemented under Supplemental Analysis 1b would benefit all of the representative species. Most of the benefits are the same as described in Alternative 1. For a description of benefits and impacts of actions implemented under Supplemental Analysis 1b that would affect riverine habitat, see Alternative 1. The effects of habitat-related actions in the Delta are also the same as described for Alternative 1. Under Supplemental Analysis 1b, losses related to conditions affecting movement and the interrelated effects on diversion are described. Although impacts attributable to conditions affecting movement are identified, actual impacts may be less because operation of Georgiana Slough and Old River barriers would consider Delta channel conditions in the lower San Joaquin River and in the central Delta that may affect striped bass, delta smelt, longfin smelt, and other Delta species.

Chinook Salmon

Effects on chinook salmon are discussed separately for fall, late fall, winter, and spring runs. All runs would benefit under implementation of Supplemental Analysis 1b compared to the No-Action Alternative.

Fall-Run Chinook Salmon. For juvenile fall-run migrating down the Sacramento River, movement into the central Delta through the DCC and Georgiana Slough would decrease from November through June compared to the No-Action Alternative. Changes compared to Alternative 1 are attributable to the installation of a barrier on Georgiana Slough. Although some conditions affecting movement would improve, reduced QWEST during April, May, and June would reduce movement out of the central and south Delta and may increase mortality for juvenile salmon, including juvenile fall-run originating from the Sacramento, San Joaquin, and Mokelumne rivers. Fall-run chinook salmon in the San Joaquin River would benefit from the closure of upper Old River, which would improve migration down the San Joaquin River past Stockton.

Late Fall-Run Chinook Salmon. Installation of the Georgiana Slough barrier under Supplemental Analysis 1b would improve habitat conditions for late fall-run chinook salmon compared to conditions under the No-Action Alternative and Alternative 1. Conditions affecting movement would be improved under Alternative 1b in response to the reduced proportion of Sacramento River flow entering the DCC and Georgiana Slough during May, June, October, and November (i.e., benefits from the Georgiana Slough barrier).

Winter-Run Chinook Salmon. Similar to late fall-run, winter-run chinook salmon would benefit from Supplemental Analysis 1b. Under Supplemental Analysis 1b, the proportion of Sacramento River flow entering the DCC and Georgiana Slough decreases during December through April and would improve movement of winter-run chinook salmon to Suisun Bay.

However, reduced QWEST (December through April) would reduce movement out of the central and south Delta. Adverse effects would be offset by fish screen improvements and reduced transport to the central Delta (i.e., benefits from the Georgiana Slough barrier).

Spring-Run Chinook Salmon. Similar to the other runs, spring-run chinook salmon would also benefit from Supplemental Analysis 1b. Less movement of fish to the central Delta would occur under Supplemental Analysis 1b in response to the reduced proportion of Sacramento River flow entering the DCC and Georgiana Slough during November through April. However, mortality may increase in response to reduced QWEST (November through April). Adverse effects would be offset by fish screen improvement and reduced transport to the central Delta (i.e., benefits from the Georgiana Slough barrier).

Steelhead Trout

Under Supplemental Analysis 1b, movement of juvenile steelhead trout toward Suisun Bay would be improved by the reduced proportion of Sacramento River flow entering the DCC and Georgiana Slough during November through May, thereby improving their survival.

Sturgeon

For a description of the beneficial and adverse impacts of actions under Alternative 1b that would affect sturgeon, see Alternative 1.

American Shad

For a description of the beneficial and adverse impacts of actions under Alternative 1b that would affect American shad, see Alternative 1.

Striped Bass

Actions under Supplemental Analysis 1b that would affect striped bass are similar to actions described under Alternative 1. Juvenile striped bass would benefit from fish screen improvements that would reduce diversion mortality. The Georgiana Slough barrier would reduce the movement into the central Delta of striped bass eggs and larvae originating in the Sacramento River. Movement toward the central Delta in the lower San Joaquin River, however, would increase compared to the No-Action Alternative, primarily in response to reduced QWEST during April and May.

Delta Smelt

Impacts on delta smelt under Supplemental Analysis 1b are similar to the impacts described for Alternative 1. Movement toward Suisun Bay, however, would decrease compared to the No-Action Alternative and Alternative 1, primarily in response to reduced QWEST from April through June. QWEST would generally increase from November through March and may increase losses of juvenile and adult delta smelt to both diversion and adverse conditions affecting movement. Less flow toward Suisun Bay and increased flow toward the SWP and CVP diversions may reduce movement out of unproductive habitat in the central Delta compared to

habitat closer to Suisun Bay. Fish screens and improved salvage operations implemented under the CVPIA, however, would reduce loss of affected fish.

Longfin Smelt

Longfin smelt would benefit from CVPIA actions under Supplemental Analysis 1b, similar to the beneficial impacts described for Alternative 1. Increased outflow during January through June and reduced diversions during April through July may increase movement of larvae and juveniles toward Suisun Bay (i.e., improved conditions affecting movement) and reduce diversion mortality. Closure of Georgiana Slough, however, would increase QWEST compared to the No-Action Alternative and may increase loss of adult, larval, and juvenile longfin smelt during January through June.

Sacramento Splittail

For a description of the beneficial and adverse impacts of actions under Supplemental Analysis 1b that would affect Sacramento splittail, see Alternative 1.

Reservoir Species

For a description of the beneficial and adverse impacts of actions under Alternative 1b that would affect reservoir species, see Alternative 1.

RESPONSE BY ENVIRONMENTAL CONDITION

The following sections describe, for each environmental condition, the species responses to CVPIA and restoration actions included in Supplemental Analysis 1b.

Water Temperature

For a description of change in water temperature conditions compared to the No-Action Alternative, see Alternative 1.

Diversion

For a description of the effects of fish screen improvements and river diversions compared to the No-Action Alternative, see Alternative 1. In the Delta, diversion impacts under Supplemental Analysis 1b would be similar to those described for Alternative 1. Construction and operation of barriers on Georgiana Slough and at the head of Old River, however, would influence diversion loss by changing flow patterns that affect movement (see Movement).

Change in Water Surface Level

For a description of change in water surface level compared to the No-Action Alternative, see Alternative 1.

Pollutants

For a description of change in pollutants compared to the No-Action Alternative, see Alternative 1.

Predation

For a description of change in predation compared to the No-Action Alternative, see Alternative 1.

Movement

In rivers, the effects of actions under Supplemental Analysis 1b would be the same as those described for Alternative 1. In the Delta, movement affected by closure of Georgiana Slough is compared to the No-Action Alternative and Alternative 1.

Outmigrating juvenile chinook salmon and steelhead trout and egg and larval striped bass are assumed to enter the DCC and Georgiana Slough in proportion to net flow diversion from the Sacramento River. Organisms carried into the central Delta by flow in the DCC and Georgiana Slough are exposed to increased adverse conditions (e.g., diversion, adverse water temperature, predation) and reduced survival compared to organisms that continue down the Sacramento River. Under Supplemental Analysis 1b, a barrier on Georgiana Slough is assumed to operate in conjunction with the DCC.

Under the No-Action Alternative, the proportion of Sacramento River flow entering the DCC and Georgiana Slough ranges from 15 percent to 50 percent from November through June. The proportion depends on the operation of the DCC and on flow in the Sacramento River. Under Supplemental Analysis 1b, the proportion of Sacramento River flow entering the DCC and Georgiana Slough would range from 0 percent to 50 percent, reflecting closure of both the DCC and Georgiana Slough. The Georgiana Slough barrier provides operations flexibility to reduce movement of juvenile chinook salmon and steelhead trout into the central Delta. Although a Georgiana Slough barrier could clearly increase survival for chinook salmon, steelhead trout, and potentially for striped bass eggs and larvae from the Sacramento River, closure could reduce movement toward Suisun Bay for chinook salmon in the central and south Delta, including chinook salmon originating from the Mokelumne and San Joaquin rivers (see attraction effects described below) and increase exposure to diversion. Losses could also increase for delta smelt, striped bass, longfin smelt, and other Delta species occurring in the lower San Joaquin River and the central Delta. As part of the restoration action, operation of Georgiana Slough and DCC barriers could be modified to provide conditions in the lower San Joaquin River and in the central Delta to benefit chinook salmon, striped bass, delta smelt, longfin smelt, and other Delta species. Under Supplemental Analysis 1b, DCC and Georgiana Slough barriers are not operated during July through October, and impacts are the same as those described for Alternative 1.

An additional barrier included in Supplemental Analysis 1b is the barrier on the head of Old River. The barrier would be closed during April and May to assist successful outmigration of juvenile fall-run chinook salmon from the San Joaquin River. Under the No-Action Alternative and Alternative 1, the proportion of San Joaquin River flow entering Old River exceeds 60

percent. Under Supplemental Analysis 1b, San Joaquin River flow could be blocked from entering Old River. The barrier would provide operations flexibility to reduce loss of juvenile chinook salmon to movement into Old River. Although an Old River barrier would reduce mortality of chinook salmon, closure would reduce movement toward Suisun Bay for species in the central Delta, including chinook salmon, delta smelt, striped bass, longfin smelt, and other Delta species. As part of the restoration action, operation of Old River barrier could be modified to provide conditions in the central Delta to benefit chinook salmon, striped bass, delta smelt, longfin smelt, and other Delta species.

Net channel flow toward Suisun Bay is assumed to provide cues that increase movement of organisms out of unproductive habitat in the central and south Delta. Under Supplemental Analysis 1b, closure of a barrier on Georgiana Slough would reduce net flow in the lower San Joaquin River toward Suisun Bay and increase net flow toward the central Delta (i.e., reduced QWEST). Flow conditions under Supplemental Analysis 1b may reduce movement of larval and juvenile striped bass and delta smelt and juvenile chinook salmon and steelhead trout out of the central and south Delta and toward Suisun Bay. As part of the restoration action, operation of Georgiana Slough and DCC barriers could be modified to reduce losses caused by reduced QWEST.

Quantity and Quality of Habitat

For a description of change in quantity and quality of habitat compared to the No-Action Alternative, see Alternative 1.

Food Web Support

The response of fish species described for Supplemental Analysis 1b in the preceding sections generally applies to food web organisms. In rivers and reservoirs, the effects of actions under Alternative 1b would be the same as described for Alternative 1.

Food web support would increase for the representative species in the Delta. The effects of habitat-related actions are the same as described for Alternative 1. Under Supplemental Analysis 1b, losses related to movement and the interrelated effects on diversion are described.

Movement of food web organisms may be affected by net channel flow in the Delta.

Flow conditions during October through June may increase the loss of food organisms to diversion because QWEST and Delta outflow (in October and November) are reduced. Under Supplemental Analysis 1b, closure of Georgiana Slough causes a reduction in QWEST compared to the No-Action Alternative and reduces the movement of food web organisms in the central Delta toward Suisun Bay (see Movement).

In addition, the upstream shift in estuarine salinity would reduce food web support for species geographically associated with a specific salinity because productivity is generally higher in the shallow shoal habitat of Suisun Bay than in the Delta. Compared to the No-Action Alternative, X2 would shift farther downstream during January, February, and March of low outflow years and would increase food web support for Sacramento splittail, delta smelt, and longfin smelt. During

July through September, Delta outflow would be less than outflow simulated for the No-Action Alternative and X2 would shift upstream. Upstream shift in X2 would reduce food web support for striped bass, delta smelt, and other species. The upstream shift would also affect production of food organisms that require specific salinity conditions.

ALTERNATIVE 2

Implementation of Alternative 2 would benefit all representative fish species by reducing loss of individual organisms, increasing habitat availability, and increasing life history diversity. Alternative 2 includes all components included in Alternative 1, plus additional flow in the San Joaquin River system (Figure III-23). In general, flows allocated to fish habitat improvement in the San Joaquin River system increase under Alternative 2 compared to Alternative 1 (Table III-4). Flow needs are based on flow recommendations in the restoration actions and were developed jointly by the Service and Reclamation (PEIS Attachment G). Benefits that accrue to aquatic species from flow-related actions include improvements in water temperature, diversion, and change in water surface level; increased access to habitat (Figure III-23); increased quantity and quality of habitat; and increased food web support (Figure III-24). All structure-related, habitat-related, and species management actions implemented under Alternative 1 would also be implemented under Alternative 2. Most river flows and reservoir operations are similar for alternatives 1 and 2.

RESPONSE BY REPRESENTATIVE SPECIES

Compared to the No-Action Alternative, actions implemented under Alternative 2 would benefit all of the representative species (Figure III-25). The actions would result in reduced loss of individuals and increased habitat availability and quality.

The following sections describe the responses for each species, based on applicable environmental conditions, to CVPIA actions included in Alternative 2. Impacts are similar to those described for Alternative 1. Specific information regarding changes expected for each environmental condition is provided under Response by Environmental Condition.

Chinook Salmon

Effects on chinook salmon are discussed separately for fall-, late fall-, winter-, and spring-runs. All runs of chinook salmon would benefit from improved ecosystem conditions (Figure III-24) in the watersheds they use (Figure III-25) under implementation of Alternative 2 compared to the No-Action Alternative (Figure III-25).

Fall-Run Chinook Salmon. For a description of the beneficial and adverse impacts of actions implemented under Alternative 2 that affect riverine habitat of the Sacramento River and its tributaries, see Alternative 1.

For the San Joaquin River and its tributaries, fall-run chinook salmon would benefit from increased habitat and food web support (Figure III-24). Increased quantity and quality of habitat and food web support result from actions that would restore spawning substrate, rearing habitat,

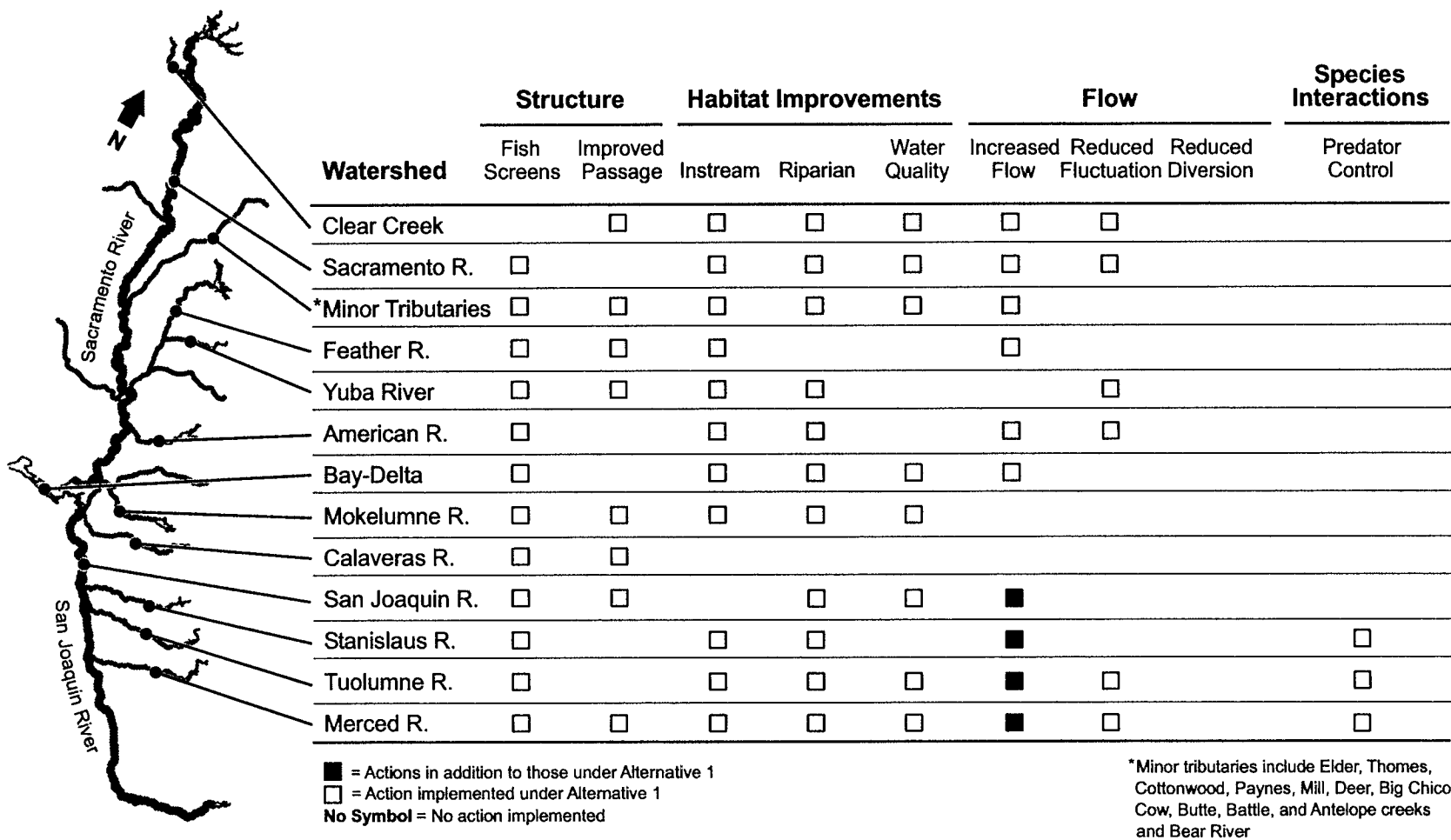


FIGURE III-23

CVPIA ACTIONS IMPLEMENTED TO BENEFIT FISH AND AQUATIC RESOURCES UNDER ALTERNATIVE 2

Draft PEIS

Environmental Consequences

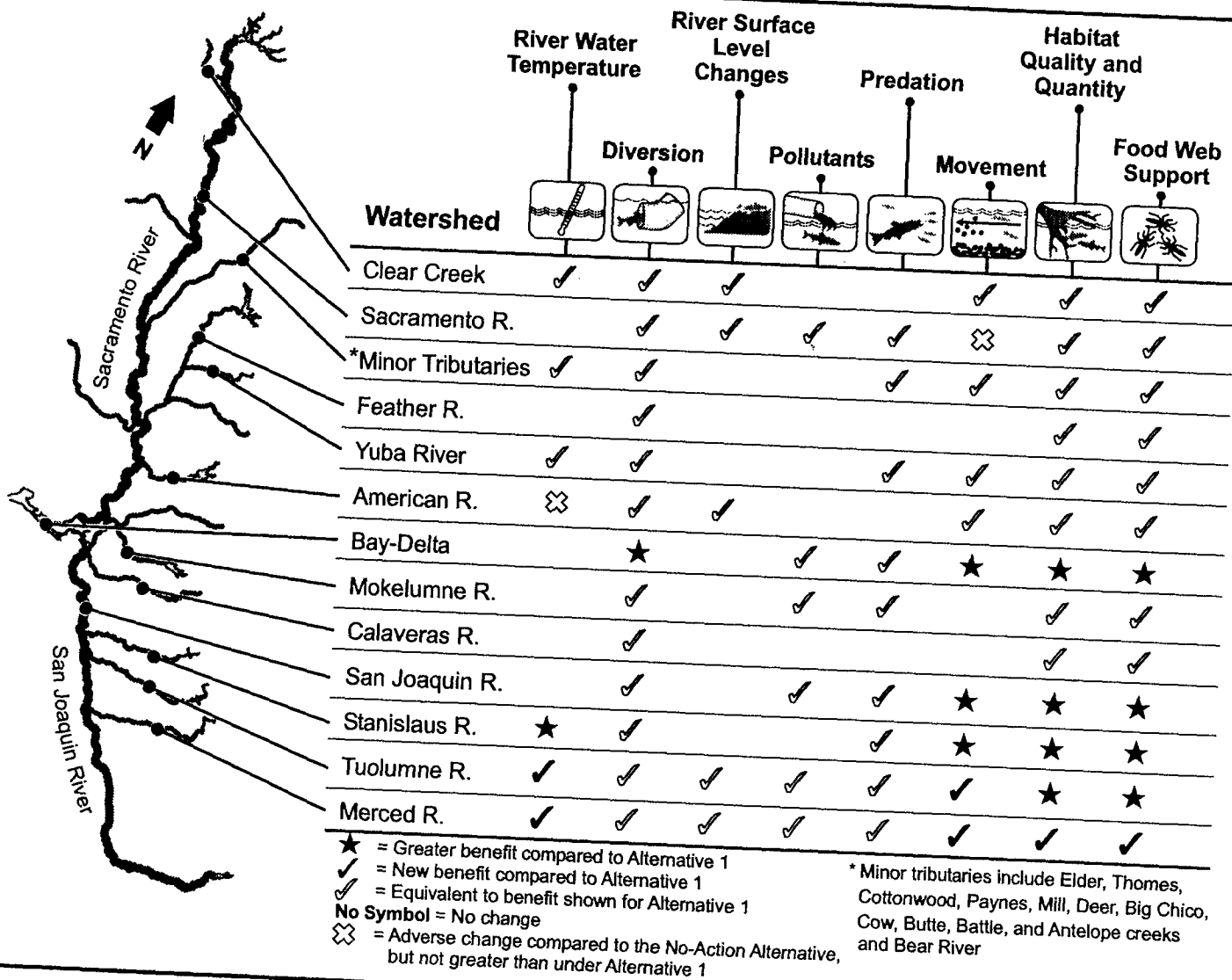


FIGURE III-24

CHANGES IN ENVIRONMENTAL CONDITIONS AFFECTING FISH POPULATIONS
UNDER ALTERNATIVE 2 COMPARED TO THE NO-ACTION ALTERNATIVE AND ALTERNATIVE 1

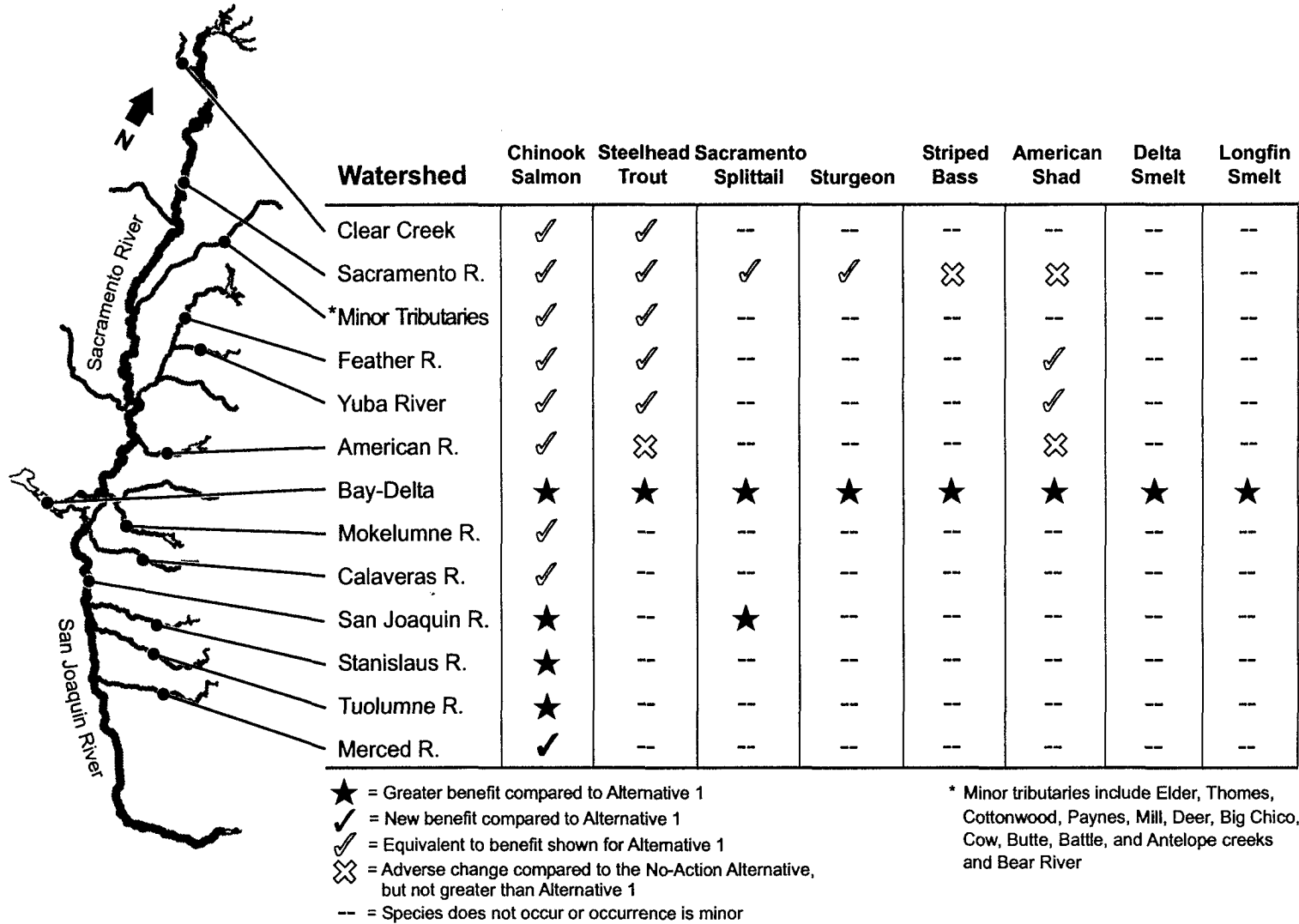


FIGURE III-25

BENEFICIAL AND ADVERSE CHANGES TO FISH SPECIES
UNDER ALTERNATIVE 2 COMPARED TO THE NO-ACTION ALTERNATIVE AND ALTERNATIVE 1

and riparian habitat. Increased flow in the Stanislaus River during October and January through June; the Tuolumne River during April through October; and the Merced River during October, April, and May would provide additional habitat for fry and juvenile rearing. In addition, increased flows could also reduce short-term water surface-level fluctuations by providing more stable conditions. Greater flows would also tend to reduce water temperature.

Fall-run chinook salmon in the San Joaquin River basin would benefit from reduced water temperature, diversion, water surface-level change, pollutant levels, predation, and improved conditions affecting movement (Figure III-24). Loss of juveniles to diversions would be reduced by fish screen improvements on the San Joaquin River and its tributaries. CVPIA actions address reservoir operations and would reduce loss of eggs, fry, and juveniles to short-term water surface-level change in the Tuolumne and Merced rivers. Inappropriate attraction flows would be reduced for the adult fall-run through construction of barriers to block access to unproductive habitat on the mainstream San Joaquin River. Predation may be reduced by isolating existing ponds from the main river flow. Water temperature would be reduced by increased flow and cooler water temperature in the Stanislaus River during March to June, benefitting juvenile fall-run chinook salmon.

On the Stanislaus River, simulated operations would increase water temperature during October and November under Alternative 2, and could increase spawning and incubation mortality. However, the difference in water temperature in Alternative 2 is relatively small compared to the No-Action Alternative, and actual water temperatures would meet the October 15 target of 56 degrees Fahrenheit through reservoir operations.

In the Sacramento-San Joaquin Delta Estuary, fall-run chinook salmon would benefit from reduced pollutant levels and diversion, improved movement, and increased quantity and quality of habitat and food web support (Figure III-24). Increased Delta outflow from January through June would dilute pollutant concentrations. Losses to diversions would be reduced by fish screen improvements and by reduced Delta diversions during April through June. For juvenile fall-run migrating down the Sacramento River, increased movement into the central Delta through the DCC and Georgiana Slough could occur during June. However, a higher QWEST during March to August would improve conditions affecting movement toward Suisun Bay for juvenile salmon in the central and south Delta, including juvenile fall-run chinook salmon originating from the Sacramento, San Joaquin, and Mokelumne rivers. Increased quantity and quality of habitat and food web support could result from actions that would restore shallow water and riparian habitats, benefiting juveniles and fry during their temporary residence and migration through the Delta.

Although the actions under Alternative 2 would benefit fall-run chinook salmon overall, some CVPIA actions could have adverse impacts in the Delta. Relative to the No-Action Alternative, diversions increase from October to February, possibly increasing diversion losses. However, this diversion mortality would be offset by fish screen improvements.

Late Fall-Run Chinook Salmon. Implementation of the CVPIA actions under Alternative 2 would improve habitat conditions for late fall-run chinook salmon compared to conditions under the No-Action Alternative. For a description of the beneficial and adverse impacts of actions implemented under Alternative 2 that affect riverine and Delta habitat for late fall-run chinook salmon, see Alternative 1.

In addition, a higher QWEST from March to June would improve the movement of juvenile salmon out of the central and south Delta toward Suisun Bay.

Winter-Run Chinook Salmon. Similar to late fall-run, winter-run chinook salmon would benefit from implementation of Alternative 2. For a description of the beneficial and adverse impacts of actions implemented under Alternative 2 that would affect riverine and Delta conditions for winter-run, see Alternative 1.

A higher QWEST during March and April would improve conditions affecting movement toward Suisun Bay for juvenile salmon in the central and south Delta.

Spring-Run Chinook Salmon. Similar to the other runs, spring-run chinook salmon would also benefit from implementation of Alternative 2. For a description of the beneficial and adverse impacts of actions implemented under Alternative 2 that would affect riverine and Delta conditions for spring-run, see Alternative 1.

A higher QWEST during March to June would improve conditions affecting movement toward Suisun Bay for juvenile salmon in the central and south Delta.

Steelhead Trout

Steelhead trout is a cool-water species with needs similar to the chinook salmon runs previously discussed. For a description of the beneficial and adverse impacts of actions implemented under Alternative 2 that would affect steelhead trout, see Alternative 1.

In addition to the beneficial and adverse impacts described under Alternative 1, juvenile steelhead trout would also benefit from a higher QWEST from March to June, which would improve conditions affecting movement toward Suisun Bay for juvenile salmon in the central and south Delta thereby reducing exposure to diversions.

Sturgeon

Implementation of the actions under Alternative 2 would improve habitat conditions for both white sturgeon and green sturgeon compared to conditions under the No-Action Alternative. For a description of the beneficial and adverse impacts of actions implemented under Alternative 2, see Alternative 1. Increased Delta outflow from January through June would shift estuarine salinity farther downstream, providing additional habitat and food web support for juvenile and adult rearing.

American Shad

American shad on the Feather and Yuba rivers and in the Delta would benefit overall from CVPIA actions implemented under Alternative 2 (Figure III-25). For a description of the beneficial and adverse impacts of actions implemented under Alternative 2 that would affect riverine and Delta conditions, see Alternative 1. Increased outflow during January to June could shift estuarine salinity downstream, thus, further increasing habitat and food web support.

Striped Bass

Striped bass would benefit from CVPIA actions implemented under Alternative 2 (Figure III-25). For a description of the beneficial and adverse impacts of actions implemented under Alternative 2, see Alternative 1.

Increased outflow from January to June could shift estuarine salinity downstream, thereby further increasing habitat and food web support. In addition, increased Delta outflow would dilute pollutant concentrations, benefiting all striped bass life stages. Movement of striped bass to the central and south Delta would be reduced in response to a higher QWEST from March to August, thereby reducing the mortality associated with exposure to Delta diversions.

Delta Smelt

Delta smelt would also benefit from CVPIA actions implemented under Alternative 2 (Figure III-25). The beneficial and adverse impacts under Alternative 2 would be similar to those described for Alternative 1. In addition, conditions affecting movement would also be improved compared to the No-Action Alternative, primarily in response to a higher QWEST from May to August.

Delta outflow would increase during January through June. Increased outflow would move estuarine salinity farther downstream, which may increase habitat availability for delta smelt and their prey and also dilute pollutant concentrations, benefiting delta smelt eggs, larvae, juveniles, and adults. Simulated outflow under Alternative 2 is generally higher in low outflow years compared to the No-Action Alternative, and habitat for food organisms may increase. Food organisms produced would be important to larval and juvenile delta smelt during February through June.

Longfin Smelt

Longfin smelt would benefit from CVPIA actions implemented under Alternative 2 (Figure III-25). Impacts under Alternative 2 would be similar to impacts described for Alternative 1. Increased outflow from January through June may increase the movement of larvae and juveniles toward Suisun Bay and reduce diversion-related losses. Increased Delta outflow during January through June under Alternative 2 would also move estuarine salinity farther downstream and may increase habitat availability for longfin smelt and, additionally, their prey. The production of food organisms during January through June due to increased habitat would be of importance to juvenile and adult longfin smelt and rearing larvae.

Sacramento Splittail

Sacramento splittail would benefit from riverine and Delta actions implemented under Alternative 2 (Figure III-25). For a description of the beneficial and adverse impacts of actions implemented under Alternative 2 that would affect the Sacramento River and its tributaries, see Alternative 1. The impacts of actions not related to flow in the Delta are the same as those described for Alternative 1.

Increased Delta outflow and the resultant downstream shift in estuarine salinity in January through June would increase spawning and rearing habitat availability and increase food web support. Increased flow in the San Joaquin River, primarily in April and May, may increase spawning and rearing habitat for splittail.

Reservoir Species

The beneficial and adverse impacts of actions implemented under Alternative 2 that affect reservoir species are the same as those described for Alternative 1, except for New Don Pedro Reservoir and Lake McClure. Effects of actions included in Alternative 2 are described here for New Don Pedro Reservoir and Lake McClure.

Overall, changes in New Don Pedro Reservoir and Lake McClure operations under Alternative 2 would have minimal effects on reservoir species. Under the No-Action Alternative and Alternative 2, monthly and annual variability in surface elevation is substantial, reflecting a response to meteorology and operations for water storage and flood control needs. The CVPIA actions implemented under Alternative 2 would decrease reservoir surface elevation in New Don Pedro Reservoir from June to August. Alternative 2 would lower reservoir surface elevations in Lake McClure for most of the year (i.e., November to August). Lower reservoir surface elevations would reduce habitat available for spawning and rearing by largemouth and spotted bass and would reduce food web support.

Under Alternative 2 operations, levels in New Don Pedro Reservoir from July through September remained elevated compared to the No-Action Alternative. In July, this could benefit all life stages of reservoir species through reduced predation, drying out of redds (desiccation), and increased food web support. In August and September, the benefits would include reduced predation and increased food web support for rearing juveniles and adults. In contrast, during May and June, drawdown may increase slightly, affecting all life stages through increased predation, nest desiccation, and increased food web support.

In Lake McClure, Alternative 2 operations reduce drawdown from July to October. Therefore, juvenile and adult rearing may benefit through reduced predation and increased food web support. In addition, spawning and incubation would benefit in July from reduced nest desiccation and predation. In June, nest desiccation would increase for the spawning and incubation life stages.

RESPONSE BY ENVIRONMENTAL CONDITION

The following sections describe, by environmental condition, the environmental responses to CVPIA actions included in Alternative 2.

Water Temperature

Water temperatures in rivers within the Sacramento River Region are the same as those described for Alternative 1. In addition, Alternative 2 would further reduce water temperatures in the San Joaquin River tributaries, compared to Alternative 1 and the No-Action Alternative. These lower water temperatures would be achieved through a combination of additional flows allocated to fish habitat improvement and CVPIA restoration actions (Figure III-23). Because of increased spring flows in the Stanislaus, Tuolumne, and Merced rivers, water temperatures would be reduced (Figure III-24). Lower temperatures would benefit rearing juvenile fall-run chinook salmon.

Diversion

Actions implemented under Alternative 2 that may reduce diversion-related losses are similar to those described for Alternative 1. Diversions in the rivers and in the Delta would remain at the same level as under Alternative 1 and the effects would be similar. For a description of the diversion effects under Alternative 2 compared to the No-Action Alternative, see Alternative 1.

In the Delta, increased inflow from the San Joaquin River and its tributaries would improve flow conditions, reducing exposure to diversions (Figure III-24). Therefore, species in central and south Delta habitats would benefit from flow conditions that improve movement toward Suisun Bay. A higher QWEST during March to August would facilitate the movement of organisms out of the central and south Delta toward Suisun Bay (see Movement) and result in reduced exposure to diversions for egg and larval striped bass, American shad, delta smelt, and longfin smelt.

Change in Water Surface Level

Rivers. The effects of implementing Alternative 2 would be the same as those described for Alternative 1.

Reservoirs. In reservoirs, simulated drawdown is the same as described for Alternative 1, except for New Don Pedro Reservoir and Lake McClure. Under Alternative 2, drawdown of New Don Pedro Reservoir would be slightly reduced from July through September. In July, this could benefit spawning, incubation, juvenile rearing, and adult rearing through reduced predation and nest dewatering. In August and September, reduced drawdown would reduce predation for rearing juveniles and adults. In contrast, during May and June, drawdown may increase, which would increase predation and nest desiccation for all life stages.

In Lake McClure, Alternative 2 operations would reduce drawdown from July to October. Juvenile and adult rearing may benefit through reduced predation. In addition, spawning and incubation would benefit in July from reduced nest dewatering and predation. In June, nest desiccation would increase, adversely impacting spawning and incubation life stages.

Pollutants

Changes in conditions affected by pollutants under Alternative 2 are similar to those described for Alternative 1. For a description of change in pollutants compared to the No-Action Alternative, see Alternative 1. Increased flow dilutes pollutants and reduces their concentrations. Under

Alternative 2, increased flows in the Sacramento-San Joaquin Delta Estuary and the Stanislaus, Tuolumne, Merced, and San Joaquin rivers would reduce pollutant concentrations.

Predation

Under Alternative 2, the predation impacts are identical to those described for Alternative 1.

Movement

There is no difference between Alternative 1 and Alternative 2 regarding barriers and their effects on fish movement (see Alternative 1). Flows in the Sacramento River and its tributaries under Alternative 2 are the same as those under Alternative 1, so conditions affecting striped bass eggs and larvae transport are the same. Under Alternative 2, the proportion of Sacramento River flow entering the DCC and Georgiana Slough is similar to the proportion under Alternative 1. The movement of juvenile chinook salmon and steelhead trout and striped bass eggs and larvae through the DCC and Georgiana Slough would be the same under Alternative 2 as described for Alternative 1.

In the San Joaquin River system and the Delta, factors that affect movement are described and compared to the No-Action Alternative. River flow is assumed to provide cues that support migration of juvenile chinook salmon and steelhead trout toward marine habitat essential for completing their life cycle. Net Delta channel flow may provide a similar cue to Delta organisms, affecting movement out of the central and south Delta.

San Joaquin River and Tributaries. Conditions affecting movement under Alternative 2 are similar to those described for Alternative 1, except that additional flows are acquired in the San Joaquin River tributaries. Alternative 2 actions increase flows as indicated by increased habitat quality and quantity in the Stanislaus, Tuolumne, and Merced rivers (Figure III-24). Simulated data for the Stanislaus River show increased flows in October and from January to June; for the Tuolumne River, flows increase from April to October; for the Merced River, flows increase in October, April, and May. Migrating juvenile fall-run chinook salmon would benefit through improved flow conditions, primarily during April and May. Pulse flows would be expected to benefit primarily juvenile fall-run chinook salmon, although other life stages and species may also benefit.

Sacramento-San Joaquin Delta Estuary. Under Alternative 2, net Delta channel flow increases which facilitates movement toward Suisun Bay and improved habitat quality and quantity (Figure III-24). Net channel flow toward Suisun Bay is assumed to provide cues that increase movement of organisms out of unproductive habitats in the central and south Delta. A higher QWEST during March to August may increase movement of larval and juvenile striped bass, delta smelt, longfin smelt, and juvenile chinook salmon (all runs) and steelhead trout out of the central and south Delta and toward Suisun Bay.

Quantity and Quality of Habitat

For the PEIS, increased flow is assumed to increase habitat for chinook salmon, steelhead trout, striped bass, American shad, green sturgeon and white sturgeon, and Sacramento splittail. In most rivers, the effects of implementing Alternative 2 would be the same as described under Alternative 1. Flow in the Stanislaus, Tuolumne, Merced, and San Joaquin rivers, however, would increase (Figure III-23). Actions to increase habitat availability by improving access are the same as described for Alternative 1. The effects of habitat restoration actions are also the same as described for Alternative 1. Effects of flow conditions on habitat under Alternative 2 are described in this section. In reservoirs, simulated reservoir surface elevation is the same as described under Alternative 1, except for New Don Pedro Reservoir and Lake McClure. Effects of Alternative 2 operations on reservoir species in New Don Pedro Reservoir and Lake McClure are described.

San Joaquin River and Tributaries. Flow increases in the Stanislaus River in October and from January to June; in the Tuolumne River from April to October; and in the Merced River during October, April, and May. Increased flow in these rivers would benefit rearing and migrating fall-run chinook salmon juveniles through greater habitat quality and quantity (Figure III-24). Spawning and rearing habitat for Sacramento splittail may also increase due to the higher flow in the San Joaquin River.

Sacramento-San Joaquin Delta Estuary. Compared to the No-Action Alternative, Alternative 2 increases Delta outflow during January through June, shifting X2 downstream and increasing habitat availability (Figure III-24). Delta and estuarine habitat is critical to all of the representative species. Delta outflow may affect habitat quantity and quality through effects on estuarine salinity. Compared to Alternative 1, X2 would shift farther downstream from January through June under Alternative 2 and would increase spawning and early rearing habitat availability and habitat quality for Sacramento splittail, delta smelt, striped bass, American shad, and longfin smelt.

Reservoir. CVPIA actions under Alternative 2 affect only New Don Pedro Reservoir and Lake McClure differently than the impacts described for Alternative 1. Reservoir water surface area plays an important role in defining reservoir fish productivity. Higher reservoir elevation (representing greater surface area) typically provides greater spawning opportunities, cover, and habitat diversity and results in more diverse and larger fish populations.

Compared to the No-Action Alternative, New Don Pedro Reservoir surface levels would decrease from June to August under Alternative 2 operations. A reduction in surface levels at that time would reduce habitat and food availability for all life stages and could result in an adverse impact on reservoir species.

Alternative 2 would lower surface levels in Lake McClure for most of the year (i.e., November to August). This would reduce habitat and food availability for all life stages and could adversely affect reservoir species.

Food Web Support

Impacts on food web support under CVPIA actions implemented under Alternative 2 would be similar to the impacts described for Alternative 1. The effects of habitat restoration actions are the same as described for Alternative 1 (Figure III-23). The response of fish species to increased flow in the San Joaquin River and its tributaries, described for Alternative 2 in the preceding sections, also generally applies to food web organisms.

In the Stanislaus, Tuolumne, Merced and San Joaquin rivers, increased flow would increase the quantity and quality of habitat available for prey organisms (Figure III-24). As previously described, greater net channel flow in the Delta under Alternative 2 (see Movement) would move food organisms and nutrients out of the central Delta and toward Suisun Bay. Therefore, the potential loss of food organisms and nutrients to diversions would be reduced. In addition, increased net channel flow would contribute to the shift of estuarine salinity farther downstream and the increase in habitat availability for food organisms (Figure III-24).

ALTERNATIVE 3

Alternative 3 includes all components included in Alternatives 1 and 2, plus acquired flows in both the Sacramento and San Joaquin River systems (Figure III-26). In Alternative 3, acquired flows could be exported when pumping capacity is available. Implementation of Alternative 3 would benefit all representative fish species improving environmental conditions and increasing habitat availability.

In general, flows allocated to fish habitat improvement in the Sacramento and San Joaquin River systems increase under Alternative 3 compared to the No-Action Alternative (Table III-3). Flow needs are based on CVPIA actions developed jointly by the Service and Reclamation (PEIS Attachment G). Benefits that accrue to aquatic species from flow-related actions include reductions in water temperature, diversion, and change in water surface level; increased access to habitat; increased quantity and quality of habitat; and increased food web support (Figure III-27).

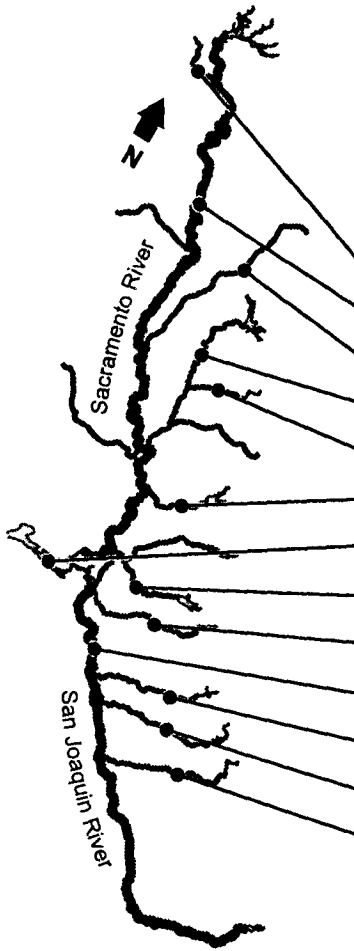
RESPONSE BY REPRESENTATIVE SPECIES

Compared to the No-Action Alternative, actions implemented under Alternative 3 would benefit all of the representative species (Figure II-28).

The following sections describe the responses of each representative species to changes in applicable environmental conditions caused by implementation of CVPIA actions included in Alternative 3. The beneficial and adverse impacts caused by Alternative 3, organized by environmental condition, are provided in the following section, Response by Environmental Condition.

Chinook Salmon

The effects on chinook salmon are discussed separately for fall-, late fall-, winter-, and spring-runs. Implementation of CVPIA actions would improve environmental conditions such as water



Watershed	Structure		Habitat Improvements			Flow			Species Interactions
	Fish Screens	Improved Passage	Instream	Riparian	Water Quality	Increased Flow	Reduced Fluctuation	Reduced Diversion	Predator Control
Clear Creek		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
Sacramento R.	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
*Minor Tributaries	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>			
Feather R.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>			
Yuba River	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
American R.	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>		
Bay-Delta	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			
Mokelumne R.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
Calaveras R.	<input type="checkbox"/>	<input type="checkbox"/>				<input checked="" type="checkbox"/>			
San Joaquin R.	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>			
Stanislaus R.	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>		<input checked="" type="checkbox"/>			<input type="checkbox"/>
Tuolumne R.	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>
Merced R.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>

☒ = Actions in addition to those under Alternative 2
☐ = Action implemented under Alternatives 1 and 2
 No Symbol = No action implemented

*Minor tributaries include Elder, Thomas, Cottonwood, Paynes, Mill, Deer, Big Chico, Cow, Butte, Battle, and Antelope creeks and Bear River

FIGURE III-26

CVPIA ACTIONS IMPLEMENTED TO BENEFIT FISH AND AQUATIC RESOURCES UNDER ALTERNATIVE 3

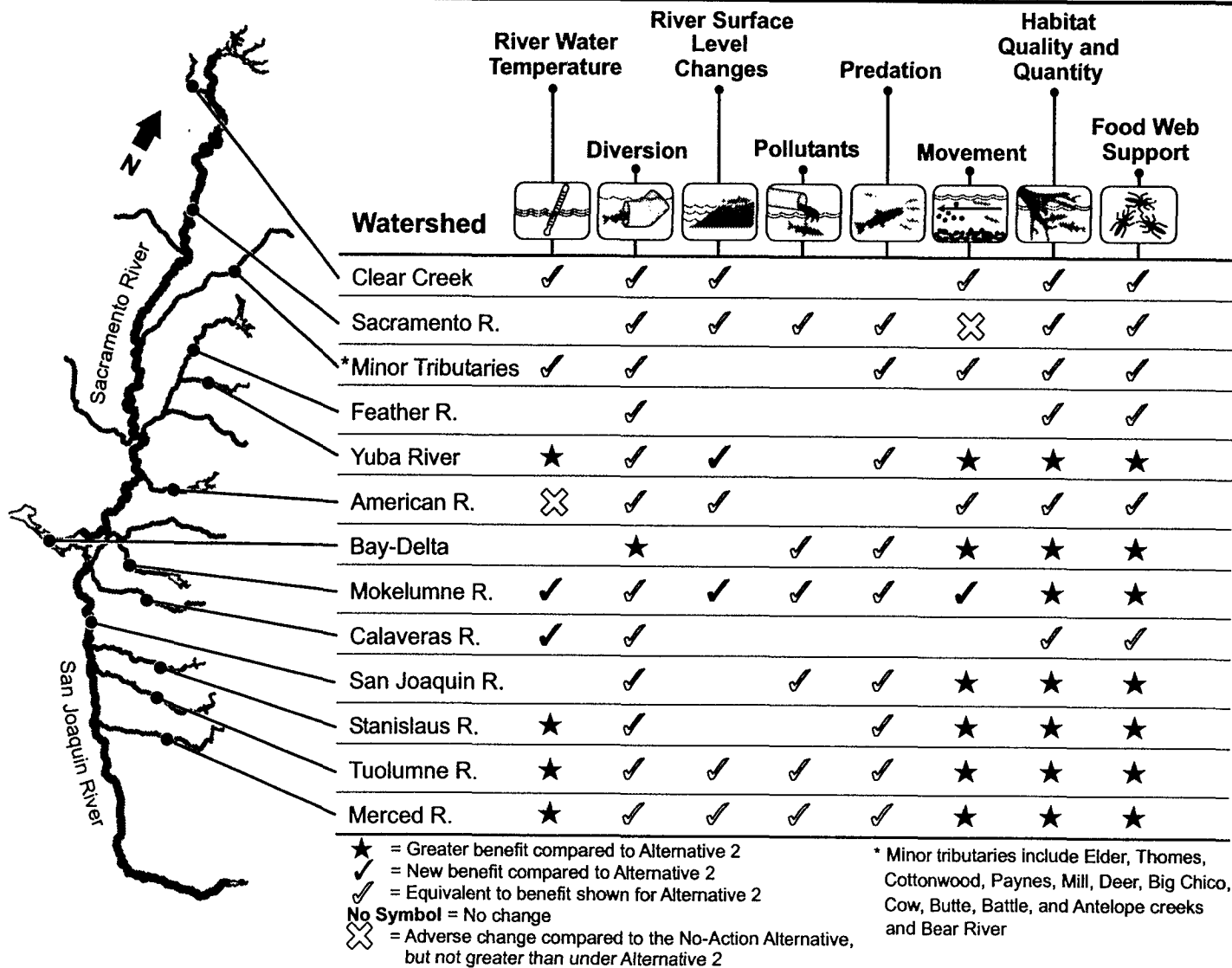


FIGURE III-27

CHANGES IN ENVIRONMENTAL CONDITIONS AFFECTING FISH POPULATIONS
UNDER ALTERNATIVE 3 COMPARED TO THE NO-ACTION ALTERNATIVE AND ALTERNATIVE 2

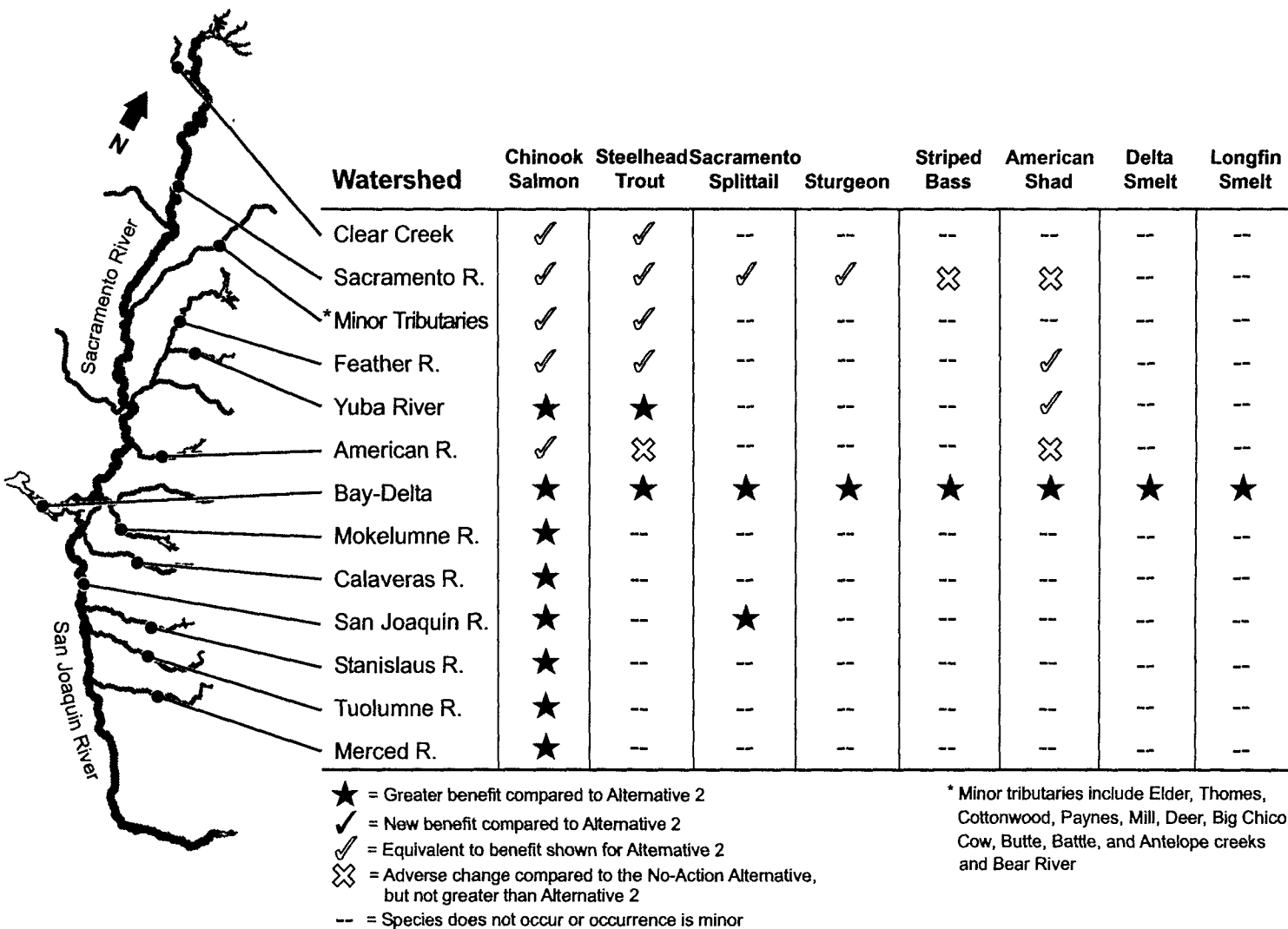


FIGURE III-28

**BENEFICIAL AND ADVERSE CHANGES TO FISH SPECIES UNDER ALTERNATIVE 3
COMPARED TO THE NO-ACTION ALTERNATIVE AND ALTERNATIVE 2**

temperature, diversion, movement, habitat quality and quantity, and food web support (Figure III-27). Under Alternative 3, chinook salmon would benefit from these improved environmental conditions in the Yuba, Mokelumne, Calaveras, San Joaquin, Stanislaus, Tuolumne, and Merced rivers and the Delta (Figure III-28) compared to the No-Action Alternative.

Fall-Run Chinook Salmon. Implementation of the CVPIA actions under Alternative 3 would improve habitat conditions for fall-run chinook salmon compared to conditions under the No-Action Alternative.

Beneficial impacts on fall-run chinook salmon in the Sacramento River and its tributaries are similar to those described for Alternative 1, whereas impacts to the San Joaquin River and its tributaries are similar to those described for alternatives 1 and 2. CVPIA actions would increase flows in the Yuba, Mokelumne, Calaveras, Stanislaus, Tuolumne, Merced, and San Joaquin rivers. The flow increase would increase quantity and quality of habitat and food web support (Figure III-27), as well as reduce water temperatures in the Stanislaus, Tuolumne, and Merced rivers between March and May.

In the Sacramento-San Joaquin Delta, fall-run chinook salmon would benefit under Alternative 3 in a manner similar to that described for Alternative 1, except a higher QWEST. During March through June, a higher QWEST would increase movement toward Suisun Bay. Increased habitat quality and quantity (Figure III-27) conditions for juvenile chinook salmon in Suisun Bay are much better compared to habitat conditions in the central and south Delta. Increased movement in the Delta would benefit juvenile fall-run chinook salmon originating from the Sacramento, Mokelumne, and San Joaquin rivers.

Late Fall-Run Chinook Salmon. Implementation of the CVPIA actions under Alternative 3 would improve habitat conditions for late fall-run chinook salmon compared to conditions under the No-Action Alternative. For a description of the beneficial and adverse impacts of actions implemented under Alternative 3 that affect riverine conditions, see Alternative 1.

In the Sacramento-San Joaquin Delta, fall-run chinook salmon would benefit under Alternative 3 in a manner similar to that described for Alternative 1, except a higher QWEST. During March through June, a higher QWEST would increase movement toward Suisun Bay. Increased habitat quality and quantity (Figure III-27) conditions for juvenile chinook salmon in Suisun Bay are much better compared to habitat conditions in the central and south Delta. Increased movement in the Delta would benefit juvenile fall-run chinook salmon originating from the Sacramento, Mokelumne, and San Joaquin rivers.

Winter-Run Chinook Salmon. Similar to late fall-run, winter-run chinook salmon would benefit from implementation of Alternative 3. Impacts under Alternative 3 are similar to impacts described for Alternative 1. Additional benefits could occur from maintaining habitat conditions essential for winter-run chinook salmon to complete the freshwater portion of their life cycle in the Calaveras River. CVPIA actions on the Calaveras River are assumed to benefit winter-run, but the available information does not support further analysis in this PEIS. A higher QWEST from December through April would improve Delta conditions supporting the movement of juvenile winter-run toward Suisun Bay.

Spring-Run Chinook Salmon. Similar to the other runs, spring-run chinook salmon would also benefit from implementation of Alternative 3. For a description of the beneficial and adverse impacts of actions implemented under Alternative 3 that affect riverine habitat, see Alternative 1.

In the Sacramento-San Joaquin Delta Estuary, impacts on spring-run chinook salmon would be similar to impacts described for Alternative 1. A higher QWEST from December through May would improve Delta conditions supporting the movement of juvenile spring-run salmon toward Suisun Bay.

Steelhead Trout

Steelhead trout is a cool-water species with needs most similar to late fall- and spring-run chinook salmon runs previously discussed. Implementation of the CVPIA actions under Alternative 3 would benefit steelhead trout overall (Figure III-28) and improve habitat conditions for steelhead trout compared to conditions under the No-Action Alternative. For a description of the beneficial and adverse impacts of actions implemented under Alternative 3, see Alternative 1 and the impacts on spring-run chinook salmon described above.

Sturgeon

Sturgeon would benefit from the implementation of Alternative 3 actions (Figure III-28). For a description of the beneficial and adverse impacts of actions implemented under Alternative 3 that would affect green and white sturgeon, see Alternative 1. Additional flow in the San Joaquin River under Alternative 3 may improve habitat conditions for sturgeon, although few are present in the San Joaquin River.

American Shad

On the Feather and Yuba rivers and in the Delta, American shad would benefit from CVPIA actions implemented under Alternative 3 (Figure III-28). Similar to the effects of Alternative 1 (see Alternative 1), American shad would benefit from increased quantity and quality of habitat and food web support, reduced diversion, and improved conditions affecting movement (Figure III-27). Under Alternative 3, increased flows on the Yuba River would provide additional habitat and food web support and improve downstream conditions affecting movement. Increased Yuba River flows would also improve conditions in the lower Feather River. Increased Delta outflow from May through August could increase habitat availability and food web support for American River shad in the Delta.

Striped Bass

Actions implemented under Alternative 3 would benefit striped bass (Figure III-28). Impacts on riverine conditions are the same as impacts described for Alternative 1.

In the Delta, conditions affecting movement toward Suisun Bay would improve compared to the No-Action Alternative and Alternative 1, primarily in response to a higher QWEST during April through August. Habitat and food availability would increase because of a downstream shift in estuarine salinity caused by increased Delta outflow from April through August.

Delta Smelt

Compared to the No-Action Alternative, benefits under Alternative 3 would accrue during all life stages of delta smelt. For a description of the beneficial impacts on delta smelt from increased quantity and quality of habitat (Figure III-27) and food web support, see Alternative 1.

In addition, reduced Delta diversions (Figure III-27) during June and July under Alternative 3 would reduce entrainment losses of larval, juvenile, and adult delta smelt. The movement of those fish in the south and central Delta toward Suisun Bay would increase (Figure III-27), increasing their survival compared to the No-Action Alternative, primarily in response to a higher QWEST from April to August. Similar to striped bass, a downstream shift in estuarine salinity would increase habitat availability and food web support.

Longfin Smelt

Similar to delta smelt, benefits to longfin smelt would accrue during all life stages under Alternative 3. For a description of the beneficial impacts on longfin smelt from increased quantity and quality of habitat and food web support in the Delta (Figure III-27), see Alternative 1.

The combination of reduced Delta diversions (Figure III-27) during June, increased Delta outflow during January through May, and an increased QWEST during April through July would increase movement of larvae and juveniles toward Suisun Bay. The movement of those fish in the south and central Delta toward Suisun Bay would increase their survival compared to the No-Action Alternative. Suisun Bay is an area of increased habitat quality and quantity compared to the south and central Delta. The increased survival of longfin smelt is also a result of a downstream shift in estuarine salinity during January through May which would increase spawning habitat and food web support. Implementation of CVPIA actions that include construction of fish screens and improved fish salvage operations would reduce entrainment and mortality of adult and juvenile longfin smelt.

Sacramento Splittail

Sacramento splittail would benefit from CVPIA actions (Figure III-26) implemented under Alternative 3 that improve movement, habitat quality and quantity, and food web support (Figure III-28). Impacts on the Sacramento River would be the same as those described for Alternative 1.

The primary benefit to Sacramento splittail would accrue during the egg, larval, and juvenile rearing life stages where improved diversion conditions (Figure III-27) would reduce the adverse effects of diversions. Adult and juvenile splittail would benefit from reduced diversions in the San Joaquin River during March through September and in the Delta during June and July; as well as reduced diversion mortality attributable to fish screen improvements. Increased flow may also provide additional habitat in the San Joaquin River. The downstream shift in estuarine salinity in October through May would increase spawning and rearing habitat availability and increase food web support in the Delta and Suisun Bay.

Additional descriptions of the beneficial and adverse impacts of CVPIA actions on splittail are provided under Alternative 1.

Reservoir Species

Both Whiskeytown and Millerton lakes remain identical in operations under Alternative 3 as under the No-Action Alternative. The beneficial and adverse impacts of actions implemented under Alternative 3 that affect reservoir species in Shasta Lake, Lake Oroville, Folsom Lake, and Camanche Reservoir are similar to those described under Alternative 1.

As a result of CVPIA actions, Camanche Reservoir would increase in surface elevation during dry years, increasing habitat and food availability during dry years. A decrease in the rate of drawdown in Camanche Reservoir under Alternative 3 would occur during June through September, which would benefit spawning and incubation.

Compared to the No-Action Alternative, New Hogan Lake, New Melones and New Don Pedro reservoirs, and Lake McClure would all have lower surface elevations under Alternative 3. Reservoir surface elevations of New Hogan Lake would be lower from March to August; New Melones Reservoir would be lower from September and October; New Don Pedro Reservoir would be lower all year; and Lake McClure would be lower between December and July. Lower reservoir elevations reduce habitat and food availability.

Reservoir drawdown primarily affects spawning and incubation life stages. Under Alternative 3, an increase in drawdown occurs in New Hogan Lake (November and May), New Melones Reservoir (August through September), New Don Pedro Reservoir (May and June), and Lake McClure (November through February and May).

Drawdowns in San Luis Reservoir increase in April and May because of reduced Delta diversions. Drawdowns affect the surface elevations during the following months until January, when San Luis Reservoir may be filled again. Increased drawdowns would have an adverse impact on spawning success, and reduced surface elevations would reduce habitat availability and food web support.

RESPONSE BY ENVIRONMENTAL CONDITION

Water Temperature

Under Alternative 3, water temperature conditions in Clear Creek; minor tributaries to the Sacramento River; and the Sacramento, Feather, and American rivers would be the same as described for Alternative 1 (Figure III-27). Water temperature conditions in the Yuba, Mokelumne, Calaveras, Stanislaus, Tuolumne, and Merced rivers would improve compared to the No-Action Alternative and Alternative 1. Increased flow, primarily during April and May, would reduce water temperature and benefit chinook salmon. Flow management changes on the Yuba River could provide temperature-related benefits to both chinook salmon and steelhead trout.

Diversion

Under Alternative 3, diversions from the Yuba, Mokelumne, and Calaveras rivers could be reduced as compared to Alternative 1 as a result of (b)(3) water management. Diversions in the remaining rivers and streams would remain the same as Alternative 1. The benefits of reduced diversions would be small because fish screen improvements would reduce entrainment and other diversion-related mortality.

Compared to the No-Action Alternative, diversion from the Delta (primarily through the CVP and SWP pumping facilities) would decrease in June and July and increase during the remainder of the year. Therefore, throughout June and July, loss of striped bass eggs, larvae, and juveniles; delta smelt adults, larvae, and juveniles; longfin smelt adults, larvae, and juveniles; American shad eggs, larvae, and juveniles; juvenile steelhead trout; juvenile chinook salmon from all runs; juvenile sturgeon; and juvenile and adult splittail would be reduced. Increased diversions during other months would increase entrainment losses; however, flow conditions affecting downstream movement improve from December to August and would reduce the exposure of most species to diversion-related impacts. During other months, fish screen improvements would reduce diversion-related impacts (see Movement). Organisms are both attracted and directed away from diversions in the central and south Delta, resulting in reduced exposure to diversion (Figure III-27).

Change in Water Surface Level

Under Alternative 3, CVPIA and restoration actions that address rapid flow fluctuation in rivers would reduce loss of eggs, larval, juvenile, and adult steelhead trout and chinook salmon compared to conditions under the No-Action Alternative (see Alternative 1). Additional actions on the Yuba and Mokelumne rivers would provide beneficial impacts related to surface elevation changes (Figure III-27).

In Whiskeytown Lake, Millerton Lake, and San Luis Reservoir, drawdown under Alternative 3 is similar to drawdown under the No-Action Alternative. Consequently, no changes in the effects from drawdown are expected under Alternative 3. Shasta and Folsom lakes are operated in essentially the same manner under Alternative 3 as under Alternative 1 (see Alternative 1).

The CVPIA actions implemented under Alternative 3 would increase drawdown in New Hogan Lake; Camanche, New Melones, and New Don Pedro reservoirs; and Lake McClure compared to the No-Action Alternative, potentially having adverse impacts on reservoir species. Increased drawdown occurs and surface elevation is lower during March through July in Camanche Reservoir; during January through August in New Hogan Lake; year round for both New Melones and New Don Pedro reservoirs; and during December through July in Lake McClure. Habitat and food availability would be reduced compared to the No-Action Alternative.

Lake Oroville under Alternative 3 compared to the No-Action Alternative has less drawdown and higher surface levels, which would reduce predation and nest desiccation compared to the No-Action Alternative.

Pollutants

For a description of the beneficial and adverse impacts of changes in pollutants under Alternative 3, see Alternative 1.

Predation

For a description of the beneficial and adverse impacts of changes in predation under Alternative 3, see Alternative 1.

Movement

Sacramento and Feather river flows and the associated impacts under Alternative 3 are essentially the same as those described for Alternative 1. Under Alternative 3, the proportion of Sacramento River flow entering the DCC and Georgiana Slough is also similar to the proportion under Alternative 1. Conditions affecting the movement of organisms in the Delta, however, improves compared to conditions under the No-Action Alternative. In addition, flow conditions affecting downstream movement improve on the Yuba, Mokelumne, Stanislaus, Tuolumne, and Merced rivers.

Under Alternative 3, flow could be acquired on the Yuba, Mokelumne, Stanislaus, Tuolumne, and Merced rivers. Increased flow and improved habitat quantity and quality (Figure III-27) is expected to benefit primarily juvenile fall-run chinook salmon migration, although flow may also maintain habitat conditions for other life stages and species.

From December through August, QWEST increases under Alternative 3 compared to the No-Action Alternative and alternatives 1 and 2. Increases in QWEST would increase the movement of juvenile chinook salmon and steelhead trout, along with larval and juvenile striped bass and delta smelt. Increased movement out of the Central and South Delta and toward Suisun Bay would improve habitat quality and quantity (Figure III-27).

Quantity and Quality of Habitat

Structural changes and habitat restoration under Alternative 3 are the same as described for Alternative 1 (see Alternative 1). Flows in the Sacramento River, Clear Creek, and Feather River under Alternative 3 are essentially the same as under Alternative 1 (see Alternative 1).

Increased flow would improve habitat conditions for anadromous salmonids in the Yuba, Mokelumne, Stanislaus, Tuolumne, and Merced rivers. Higher flows provide improved habitat conditions and increased habitat quality and quantity (Figure III-27) rearing habitat. Flows in the San Joaquin River system under Alternative 3 are typically higher than under the No-Action Alternative and Alternative 1.

On the Calaveras River, flow decreases from May through September compared to the No-Action Alternative and Alternative 1. Additional benefits could occur from maintaining habitat conditions essential for fall-run chinook salmon to complete the freshwater portion of their life cycle in the Calaveras River. The available information does not support further analysis of the Calaveras River in this PEIS.

Compared to the No-Action Alternative and alternatives 1 and 2, X2 would shift farther downstream from November to June under Alternative 3. This shift would increase habitat quality and quantity (Figure III-27). Increased habitat would increase the availability and quality of spawning and early rearing habitat for Sacramento splittail, delta smelt, and longfin smelt (see Alternative 1).

For Whiskeytown Lake, Camanche Reservoir, New Hogan Lake, and Millerton Lake, surface elevation under Alternative 3 is similar to surface elevation under the No-Action Alternative. Consequently, no changes in the effects of surface elevation are expected under Alternative 3 compared to the No-Action Alternative. Changes in drawdown under Alternative 3 operations in Shasta Lake, Lake Oroville, Folsom Lake, and New Melones and San Luis reservoirs are similar to or slightly better than conditions under Alternative 1 (see Alternative 1), but the elevations are still generally lower than reservoir elevations under the No-Action Alternative. Compared to the No-Action Alternative, surface elevations at New Don Pedro Reservoir would substantially decrease year round under Alternative 3 operations. Surface elevations in Lake McClure would be lower from December through July.

Food Web Support

Impacts on food web support as a result of habitat restoration under Alternative 3 would be identical to those described for Alternative 1. Under Alternative 3, food web support would increase through reduced diversion losses and increased habitat (Figure III-27). Increased flow in the Yuba, Mokelumne, Stanislaus, Tuolumne, and Merced rivers would increase food web support under Alternative 3.

The movement of food web organisms may be affected by net channel flow in the Delta. As indicated by a higher QWEST, flow conditions under Alternative 3 may increase movement of food web organisms out of the central and south Delta and toward Suisun Bay from April to August. The loss of food web organisms to central and south Delta diversions would be reduced.

Compared to the No-Action Alternative and alternatives 1 and 2, X2 would shift farther downstream from October through June during most years and would increase food web support for Sacramento splittail, delta smelt, and longfin smelt. Other impacts on food web support under Alternative 3 are the same as those described for Alternative 1.

ALTERNATIVE 4

Alternative 4 includes all components of Alternative 3. In addition, acquired flows are used to meet Delta flow needs, including increased Delta outflow. Alternative 4 would have additional beneficial impacts from CVPIA actions (Figure III-29) resulting in improved environmental conditions (Figure III-30) in the Delta relative to the previous alternatives.

Implementation of Alternative 4 would benefit all representative fish species (Figure III-31) by improving environmental conditions and increasing habitat availability.

In general, flows in the Sacramento and San Joaquin River basins and the associated beneficial and adverse impacts are the same as the impacts described for Alternative 3 (Table III-3). Flow acquisitions are based on recommendations developed by Reclamation and the Service as part of the Anadromous Fish Restoration Program (PEIS Attachment G).

RESPONSE BY REPRESENTATIVE SPECIES

Compared to the No-Action Alternative, actions implemented under Alternative 4 would benefit all of the representative species. Impacts in rivers are the same as those described for Alternative 1.

Chinook Salmon

Effects on chinook salmon are discussed separately for fall-, late fall-, winter-, and spring-runs. All runs of chinook salmon would benefit from improved ecosystem conditions (Figure III-30) in the watersheds they use (Figure III-31) under implementation of Alternative 4 compared to the No-Action Alternative.

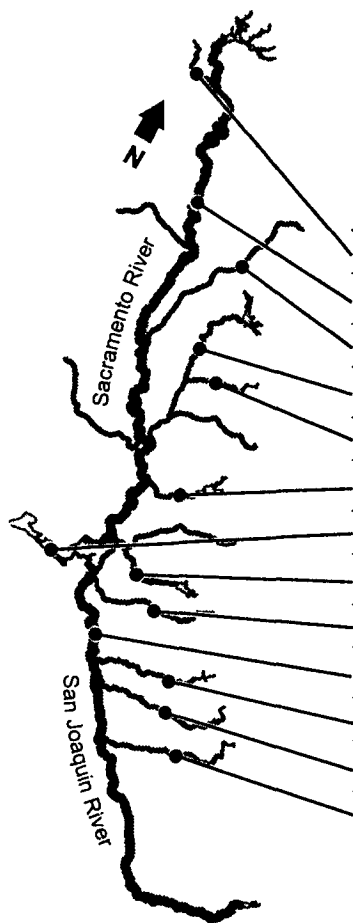
Fall-Run Chinook Salmon. Implementation of the CVPIA actions under Alternative 4 would improve ecosystem conditions which benefit fall-run chinook salmon compared to conditions under the No-Action Alternative (Figure III-30).

In the Sacramento-San Joaquin Delta Estuary, entrainment and impingement would be reduced by fish screen improvements and by reduced Delta diversion from April through June. For juvenile fall-run chinook salmon that migrate down the San Joaquin River, a higher QWEST from February through June would improve conditions affecting movement toward Suisun Bay. Juvenile fall-run originating in the Sacramento and Mokelumne rivers would also benefit.

Late Fall-Run Chinook Salmon. In the Sacramento-San Joaquin Delta Estuary, juvenile late fall-run chinook salmon would benefit from reduced Delta diversions from April through September.

Increases in QWEST during May, June, and October would improve conditions facilitating movement toward Suisun Bay for juvenile salmon in the central and south Delta, including juvenile late fall-run originating in the Sacramento River. Under Alternative 4, DCC closure during November would reduce the presence of migrating juvenile late fall-run chinook salmon in the central Delta and further improve conditions affecting movement.

Winter-Run Chinook Salmon. In the Sacramento-San Joaquin Delta Estuary, juvenile winter-run would benefit from reduced Delta diversion in April and May. Flows through the DCC and Georgiana Slough decrease up to 40 percent from the No-Action Alternative in



Watershed	Structure		Habitat Improvements			Flow			Species Interactions
	Fish Screens	Improved Passage	Instream	Riparian	Water Quality	Increased Flow	Reduced Fluctuation	Reduced Diversion	Predator Control
Clear Creek		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
Sacramento R.	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
*Minor Tributaries	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			
Feather R.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>			
Yuba River	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>		
American R.	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>		
Bay-Delta	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	
Mokelumne R.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
Calaveras R.	<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>			
San Joaquin R.	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			
Stanislaus R.	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>			<input type="checkbox"/>
Tuolumne R.	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>
Merced R.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>

☒ = Actions in addition to those under Alternative 3
☐ = Action implemented under Alternatives 1, 2, and 3
 No Symbol = No action implemented

*Minor tributaries include Elder, Thomes, Cottonwood, Paynes, Mill, Deer, Big Chico, Cow, Butte, Battle, and Antelope creeks and Bear River

FIGURE III-29

CVPIA ACTIONS IMPLEMENTED TO BENEFIT FISH AND AQUATIC RESOURCES UNDER ALTERNATIVE 4

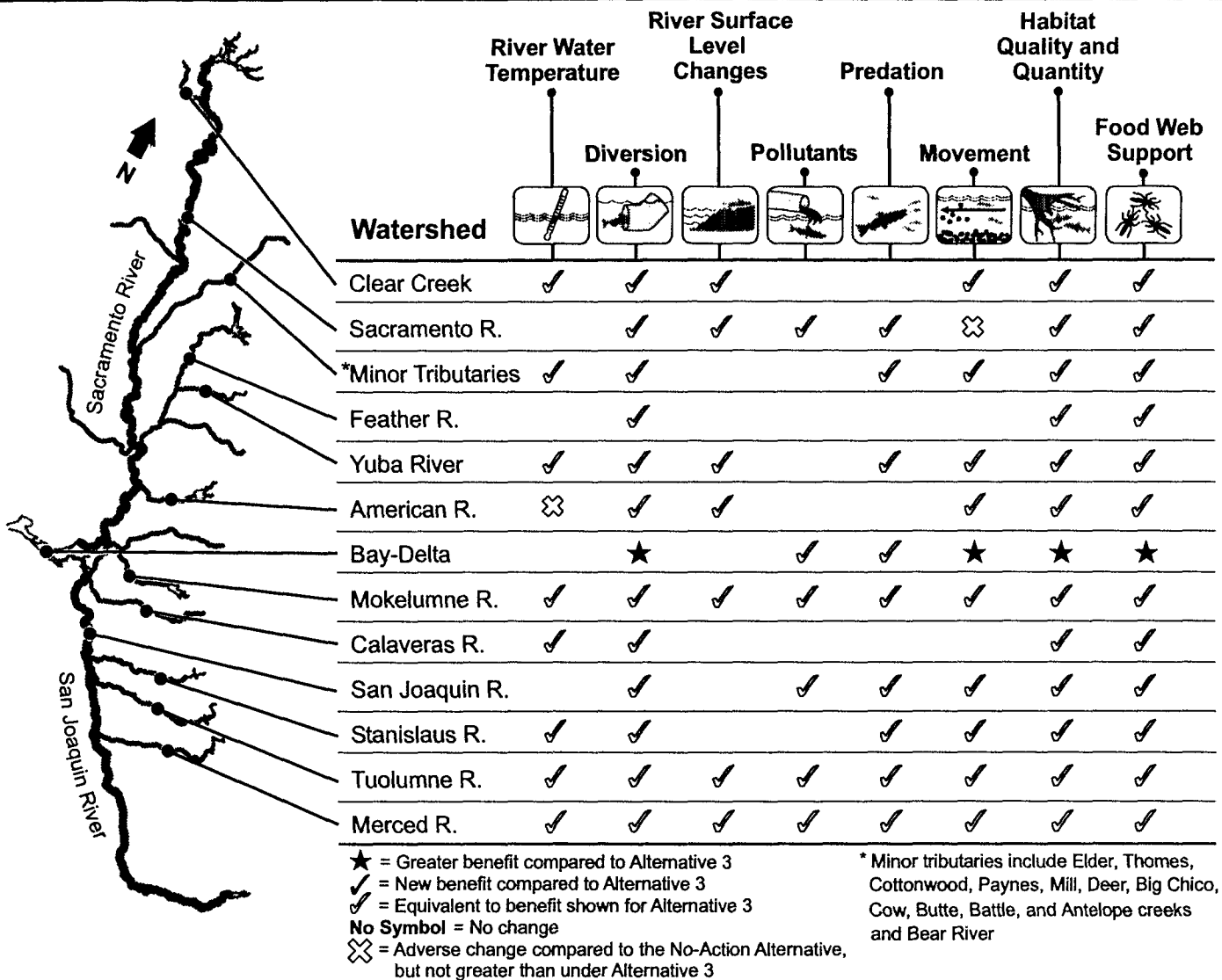


FIGURE III-30

CHANGES IN ENVIRONMENTAL CONDITIONS AFFECTING FISH POPULATIONS
UNDER ALTERNATIVE 4 COMPARED TO THE NO-ACTION ALTERNATIVE AND ALTERNATIVE 3

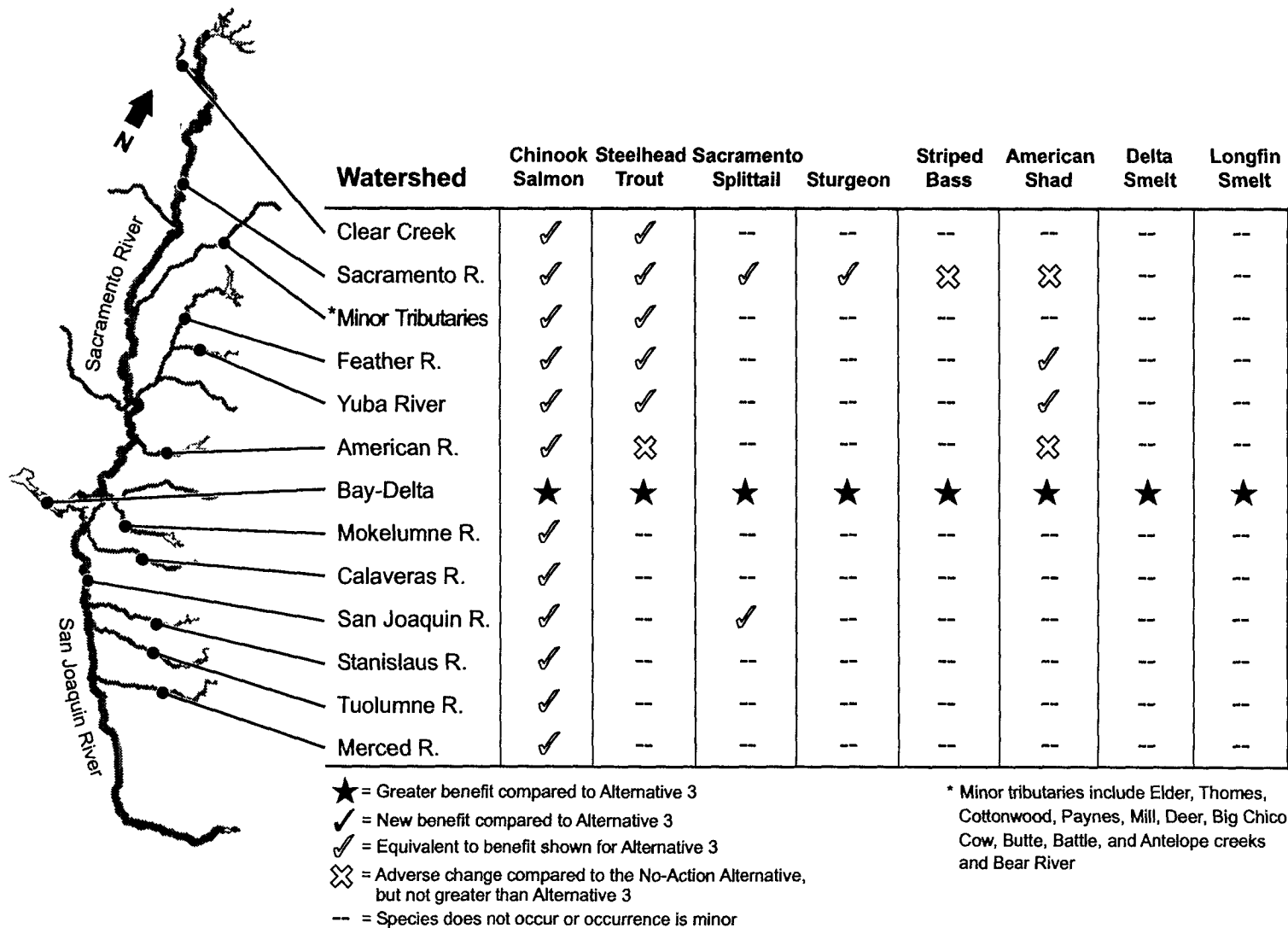


FIGURE III-31

**BENEFICIAL AND ADVERSE CHANGES TO FISH SPECIES
UNDER ALTERNATIVE 4 COMPARED TO THE NO-ACTION ALTERNATIVE AND ALTERNATIVE 3**

December and January. The proportion of Sacramento River flow diverted through the DCC and Georgiana Slough decreases in December and January by about 10 to 15 percent. Therefore, survival of migrating juvenile winter-run chinook salmon should increase. A higher QWEST from December through June, compared to the No-Action Alternative and alternatives 1 through 3, would improve conditions affecting movement through the Delta.

Spring-Run Chinook Salmon. In the Sacramento-San Joaquin Delta Estuary, spring-run chinook salmon would benefit from reduced Delta diversion in November, March, and April. Flow through the DCC and Georgiana Slough decrease up to 40 percent from the No-Action Alternative in November to January. The proportion of Sacramento River flow diverted through the DCC and Georgiana Slough decreases in November to January by about 10 to 15 percent. Therefore, migrating juvenile spring-run chinook salmon would experience increased survival because of favorable movement toward Suisun Bay.

Steelhead Trout

Beneficial and adverse impacts on steelhead trout are the same as those described above for spring-run chinook salmon.

Sturgeon

Implementation of the actions under Alternative 4 would benefit green and white sturgeon (Figure III-31) through improved habitat conditions compared to conditions under the No-Action Alternative. In the Sacramento-San Joaquin Delta Estuary, rearing adults and juveniles and migrating juveniles would benefit from reduced Delta diversions from April through August.

American Shad

In the Sacramento-San Joaquin Delta Estuary, benefits to American shad would accrue during all life stages in response to reduced pollutant levels and diversions and improved quantity and quality of habitat and food web support (Figure III-30). Under Alternative 4, Delta diversions during April through June would generally decrease, leading to decreased entrainment of eggs and larvae. Juvenile shad would benefit from reduced Delta diversions from June through November. Reduced diversions would lead to reduced diversion-related losses and improve conditions affecting movement through the Delta.

Striped Bass

Striped bass would benefit from CVPIA actions implemented under Alternative 4 compared to the No-Action Alternative (Figure III-31). In addition to the benefits previously described for alternatives 1 through 3, reduced Delta diversions from April through September would lead to reduced entrainment and impingement of egg, larval, and juvenile striped bass under Alternative 4. Conditions affecting movement would improve compared to the No-Action Alternative, primarily in response to a higher QWEST from February through October and a downstream shift in estuarine salinity in all months.

Delta Smelt

Delta smelt would also benefit from CVPIA actions implemented under Alternative 4 (Figure III-31). Reduced Delta diversions under Alternative 4 from April through September would reduce loss of larval, juvenile, and adult delta smelt. Conditions affecting movement toward Suisun Bay would be improved compared to the No-Action Alternative and alternatives 1 through 3, primarily in response to a higher QWEST from April through July and the downstream shift in estuarine salinity in all months.

Longfin Smelt

Longfin smelt would benefit from CVPIA actions implemented under Alternative 4 compared to the No-Action Alternative (Figure III-31). Delta outflow would increase in all months under Alternative 4, which would move estuarine salinity further downstream and may increase habitat availability for longfin smelt and, additionally, their prey. Reduced Delta diversion during April to June under Alternative 4 would reduce entrainment and impingement of all life stages. A higher QWEST, Delta outflow, and reduced diversions would improve conditions affecting movement of larvae and juveniles toward Suisun Bay and reduced diversion mortality from December through June.

Sacramento Splittail

Implementation of the actions under Alternative 4 would benefit Sacramento splittail overall (Figure III-31). Adult and juvenile splittail would benefit from reduced diversions in the Delta during April through September; as well as reduced diversion mortality attributable to fish screen improvements (Figure III-30). Downstream shift in estuarine salinity during all months would increase spawning and rearing habitat availability and increase food web support.

Reservoir Species

The beneficial and adverse impacts of actions implemented under Alternative 4 are the same as those described for Alternative 3, except for San Luis Reservoir.

Drawdowns in San Luis Reservoir increase in April and May because of reduced Delta diversions, affecting spawning, incubation, and rearing of reservoir species. Drawdowns reduce surface elevations in subsequent months and would adversely affect habitat availability and food web support.

RESPONSE BY ENVIRONMENTAL CONDITION

The following sections describe, for each environmental condition, the species responses to CVPIA and restoration actions included in Alternative 4.

Water Temperature

Temperature conditions and associated impacts under Alternative 4 would be the same as those described for Alternative 3.

Diversion

For a description of the effects of fish screen improvements and river diversions compared to the No-Action Alternative, see alternatives 1, 2, and 3.

Compared to the No-Action Alternative, diversion from the Delta (primarily through the CVP and SWP pumping facilities) would decrease from April through September and increase during October through December (in low-diversion years only) and January through March. During April through September, decreased diversion compared to the No-Action Alternative would reduce entrainment and impingement of striped bass eggs, larvae, and juveniles; delta smelt adult, larvae, and juveniles; longfin smelt adult larvae and juveniles; American shad eggs, larvae, and juveniles; juvenile steelhead trout; juvenile chinook salmon from all runs; juvenile sturgeon; and juvenile and adult splittail. From October through March, increased Delta diversion would increase losses of juvenile striped bass; juvenile and adult delta smelt; adult longfin smelt; juvenile American shad; juvenile steelhead trout; and juvenile late fall-, winter-, and spring-run chinook salmon. Fish screen improvements and improved conditions affecting movement, however, would reduce any losses attributable to increased diversion.

Compared to the No-Action Alternative, conditions affecting movement would partially determine the effects of diversion and the potential benefit of reduced diversion (see Movement). Flow conditions affecting movement may reduce the presence of juvenile chinook salmon and larval and juvenile striped bass and delta smelt in the central and south Delta from June through August and November through January, further reducing diversion mortality.

Change in Water Surface Level

In rivers, the effects of implementing Alternative 4 would be the same as those described for alternatives 1 and 3. In reservoirs, simulated drawdown is the same as described for alternatives 1 and 3, except for San Luis Reservoir.

Under Alternative 4, increases in drawdown at San Luis Reservoir during April and May would increase the loss of spawning, incubation, and rearing life stages.

Pollutants

For a description of change in pollutant conditions compared to the No-Action Alternative, see Alternative 1.

Predation

For a description of change in predation compared to the No-Action Alternative, see Alternative 1.

Movement

River flow under Alternative 4 is essentially the same as under Alternative 3. For a description of conditions affecting movement in riverine systems compared to the No-Action Alternative, see alternatives 1, 2, and 3.

Flow conditions affecting movement out of the central Delta and toward Suisun Bay change as a result of reduced Delta diversions and reduced flow down the DCC and Georgiana Slough. Under Alternative 4, the Old River flow diversion is essentially the same as under Alternative 1.

The proportion of Sacramento River flow entering the DCC and Georgiana Slough is similar to the proportion under Alternative 1, except during November through January, when closure of the DCC gates blocks flow from the Sacramento River. Reduced flow in the DCC and Georgiana Slough would reduce movement of organisms from the Sacramento River into the central Delta. Therefore, compared to the No-Action Alternative, conditions affecting movement in October through January would be improved (Figure III-30), which would have a beneficial impact on juvenile chinook salmon, primarily spring-run and winter-runs.

Net Delta channel flow toward Suisun Bay is assumed to provide cues that increase movement of organisms out of unproductive habitat in the central and south Delta. As indicated by a higher QWEST compared to the No-Action Alternative, flow conditions under Alternative 4 would increase movement of larval and juvenile striped bass and delta smelt and juvenile chinook salmon and steelhead trout. Increased movement out of the central and south Delta and toward Suisun Bay during April through September would improve habitat quality and quantity (Figure III-30). Compared to alternatives 1, 2, and 3, QWEST and Delta outflow would increase in all months.

Quantity and Quality of Habitat

In rivers, the effects of implementing Alternative 4 would be the same as described for alternatives 1 through 3. In the Delta, the effects of habitat restoration actions are the same as described for Alternative 1, but flow effects would differ, resulting in greater habitat benefits. Effects of Delta flow conditions on the quantity and quality of habitat under Alternative 4 are described in this section. Simulated reservoir surface elevation is the same as described for Alternative 1, except for San Luis Reservoir.

Sacramento-San Joaquin Delta Estuary. Delta outflow may affect habitat through effects on estuarine salinity. Increased outflow and location of X2 downstream of the Delta and in Suisun Bay increase habitat availability (Figure III-30). Compared to the No-Action Alternative, X2 would shift farther downstream year round and would increase the availability and quality of spawning and early rearing habitat for Sacramento splittail, delta smelt, and longfin smelt.

Reservoirs. Alternative 4 operations would reduce San Luis Reservoir surface elevation compared to the No-Action Alternative. Lower surface elevation would reduce habitat available for spawning and rearing by largemouth and spotted bass. Surface elevation, however, decreases during high storage years and increases in lower storage years.

Food Web Support

The response of fish species described for Alternative 4 in the preceding sections generally applies to food web organisms as well. For a description of changes in food web support compared to the No-Action Alternative for rivers, see Alternative 1. In the Delta, the effects of habitat restoration actions are the same as described for Alternative 1, but flow and diversion effects differ.

Changes in entrainment in Delta diversions under Alternative 4 would affect food web support. Compared to the No-Action Alternative, diversion from the Delta (primarily through the CVP and SWP pumping facilities) would decrease from April through September and increase during October through January (during some simulated years) and February through March. Decreased diversion would reduce loss of food web organisms, nutrients, and organic carbon during April through September, a primary period of production in the Delta. As indicated by a higher QWEST, flow conditions under Alternative 4 may increase movement of food web organisms out of the central and south Delta and toward Suisun Bay.

A downstream shift of estuarine salinity in response to reduced Delta outflow in all months may increase food web support in the Delta and Suisun Bay.

SPECIAL-STATUS SPECIES

The No-Action Alternative implements provisions designed to protect special-status species using tributaries of the Sacramento-San Joaquin Delta. The 1993 Winter-run Chinook Salmon Biological Opinion identifies habitat requirements (water temperature and operation requirements in the Sacramento River) to protect this species. These requirements may contribute in varying degrees to the protection of other special-status species using the Sacramento River, including spring-run chinook salmon and steelhead trout. Similarly, the Delta Smelt Biological Opinion identifies habitat requirements for delta smelt and provides habitat and transport conditions for estuarine species. These provisions also contribute to the protection of other Delta species, such as longfin smelt, which is listed as a species of concern.

Alternatives 1 through 4 contain CVPIA actions that include structural, habitat restoration, and flow-related actions. These actions would be implemented in Central Valley watersheds (Tables III-2, III-3 and III-4, and PEIS Attachment G) and provide enhanced ecosystem conditions for special-status species using those watersheds. Within the discussion of each alternative, the impacts on representative species are identified in detail. The impacts on representative species overlap with those impacts on special-status species using the tributaries of the Sacramento-San Joaquin Delta. Alternatives 1 through 4 implement (b)(2) Water Management actions in Clear Creek and the Sacramento, American, and Stanislaus rivers. Alternative 4 also includes (b)(2) Water Management actions in the Delta. These flow actions would enhance the existing benefits of other CVPIA actions, such as structural and habitat restoration actions, through synergy. An example would be the benefits observed when both flow actions and riparian corridor habitat restoration actions occur. The benefits would be much broader than those benefits observed without flow actions that affect that stream.

Alternatives 2 through 4 include acquisition of water from willing sellers to provide additional instream flow toward meeting AFRP target flows. Alternative 2 would provide additional instream flow on the Stanislaus, Tuolumne, and Merced rivers. Alternatives 3 and 4 would provide additional instream flow on the Stanislaus, Tuolumne, and Merced rivers, as well as on the Yuba, Bear, Mokelumne, and Calaveras rivers.